EDUCATION AND INEQUALITY IN DIGITAL OPPORTUNITIES

Differences in Digital Engagement
Among Finnish Lower and Upper Secondary School Students

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Tiivistelmä

Tämän väitöskirjan tavoitteena on laajentaa näkemystä digitaaliteknologioista koulutuksessa korostamalla teknologian mahdollistamia digitaalisia affordansseja digitaalisten laitteiden ja sähköisten oppimateriaalien opetuskäyttöön sekä digitaalisen pedagogiikkaan rajautuvan näkökulman sijaan. Tosiasia, etteivät digitaaliset toimintapotentiaalit ole yhtäläisesti avoinna kaikille edellyttää huomion kiinnittämistä digitaaliseen eriarvoisuuteen suhteellisena ilmiönä, joka rajoittaa yksilöiden kykyä hyödyntää tarjoutuvia affordansseja. Tämä tutkimus keskittyy koulutuksen kontekstissa sosiaalisiin hierarkioihin, jotka myötävaikuttavat digitaalisen osallisuuden epätasaiseen jakautumiseen määrittäen yksilöiden asemaa suhteessa digitaalisiin affordansseihin.

Näistä teoreettisista lähtökohdista jäsentyvät tämän väitöskirjatutkimuksen kysymykset: Missä määrin sosiaaliset rakenteet, erityisesti sukupuoli, ikä ja koulutusvalinnat, määrittävät 12–22-vuotiaiden suomalaisten digitaalisia taitoja ja käyttötottumuksia? Sekä, missä määrin ja millä tavoin suomalaisten perus- ja toisen asteen opiskelijoiden osaamisesta ja käyttötottumuksista koostuva digitaalinen osallisuus kasautuu tietyille yksilöille? Tutkimuksen empiirinen osuus koostuu viidestä alkuperäisestä artikkelista, jotka hyödyntävät kahta otosta suomalaisista opiskelijoista analysoiden kaikkiaan 11 820 opiskelijan digitaalisia käyttötottumuksia ja digitaalista osaamista.

Sukupuoli sosiaalisena kategoriana tuottaa eroja opiskelijoiden digitaaliseen osaamiseen ja digitaalisiin käyttötottumuksiin. Tulokset osoittavat, että sukupuolten väliset erot digitaalisessa osallisuudessa suomalaisten perus- ja toisen asteen oppilaiden keskuudessa ovat suurelta osin aihespesifejä yhdistyen sukupuolittuneisiin mieltymyksiin, toisin sanoen erilaiseen orientoitumiseen digitaalitekniikkaa ja potentiaalisia digitaalisia affordansseja kohtaan. Näiden mieltymysten erottuessa selvästi tutkitussa 12–22-vuotiaita koskevassa aineistossa, on oletettavaa, että erot kehittyvät jo varhaisemmassa vaiheessa lapsuutta ja nuoruutta.

Ikä, jopa nuorten Internet-käyttäjien keskuudessa, vaikuttaa sekä digitaaliseen osaamiseen että käyttötottumuksiin. Iän merkitys itsenäisenä muuttujana nuorten keskuudessa selittyy etenkin sillä, että digitaaliteknologian käyttö monipuolistuu iän myötä. Erityisesti juuri käyttökokemusten monipuolisuus kartuttaa nuorten digitaalista osaamista.

Koulutus todetaan merkittävimmäksi yksittäiseksi tekijäksi, joka aiheuttaa eroja nuorten digitaaliseen osaamiseen ja käyttötottumuksiin. Se on yhtäältä kategorinen sosiaalinen hierarkia, sillä koulutustason nousu lisää digitaalista osallisuutta. Toisaalta tulokset osoittavat huomattavia eroja saman koulutusasteen sisällä, sillä osaaminen ja hyödylliset käyttökokemukset kertyvät todennäköisimmin niille opiskelijoille, jotka opiskelevat miesvaltaisilla koulutusaloilla. Sukupuolittuneisuus korostuu etenkin opiskelijoiden ilmaisemassa kiinnostuksessa ICT-alasta tulevaisuuden jatkokoulutus- tai ammattialana. Opiskelijoiden teknologia-mieltymysten ja koulutusvalintojen voimakas sukupuolittuneisuus vahvistavat toinen toisiaan ja lisäävät näin tulevien informaatioyhteiskunnan kansalaisten keskuudessa sukupuoleen perustuvia jakoja niin digitaalisessa osallisuudessa kuin myös mahdollisuuksissa hyödyntää tarjoutuvia digitaalisia affordansseja.

Tutkimus korostaa sosiologisen tarkastelun tärkeyttä teknologian ja siihen liittyvän sosiaalisen toiminnan merkityksen ymmärtämiseksi koulutuksen kontekstissa. Väitöskirjan tulokset osoittavat, että sukupuoli, ikä ja sukupuolittuneet koulutusvalinnat määrittävät suomalaisnuorten digitaalista osaamista ja käyttökokemuksia. Digitaalinen osallisuus osoittautuu luonteeltaan kasautuvaksi; digitaaliset taidot ja teknologioiden käyttö ovat toisiinsa kietoutuneita ja toisiaan vahvistavia. Yhdistelmällisyys ja peräkkäisyys ovatkin suomalaisopiskelijoiden digitaalisten valmiuksien tunnuspiirteitä. Siinä missä yhdistelmällisyys luonnehtii digitaalisen osallisuuden kumuloitumista tietyille yksilöille, peräkkäisyys viittaa todennäköisyyteen, että kyseiset yksilöt myös hyötyvät eniten käytön myötä tarjoutuvista digitaalisista affordansseista. Äärimmillään peräkkäisyys digitaalisen osallisuuden tunnuspiirteenä merkitsee polkua digitaaliseen menestykseen tai syrjäytymiseen tehden siitä informaatioyhteiskunnassa tärkeän koulutuspoliittisen kysymyksen.

Avainsanat: Digitaaliset affordanssit, digitaalinen eriarvoisuus, koulutus, koulutusvalinnat, sukupuolittuneisuus

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Abstract

The purpose of this work is to broaden the debate on digital technology in education by emphasising the digital affordances enabled by these technologies instead of focusing on the integration of digital devices and learning materials and digital pedagogy into educational practices. Digital action potentials are not equally open to everyone, requiring the scrutinisation of digital inequality as a relative issue limiting the abilities of individuals to benefit from these opportunities. In the context of education, this dissertation concentrates on the social structures affecting the unequal distribution of digital engagement which determines individual's positioning in relation to digital affordances.

These theoretical backgrounds construe the following research questions: To what extent do social structures, specifically gender, age, and educational choices, determine the digital engagement of 12–22-year-old Finns? And, to what extent and in what ways does digital engagement accumulate, as exhibited by certain individuals more than others among Finnish lower and upper secondary school students? An empirical part answering these questions consist of five original articles utilising two samples of Finnish lower and upper secondary school students. In total, the 11,820 students' digital usage habits and digital skills are analysed through multivariate statistical methods.

Gender as a social category appears to be producing differences in students' digital engagement. The results indicate that gender differences in digital engagement among Finnish lower and upper secondary school students are largely domain-specific and related to gendered preferences and interests. In other words, tendencies towards the ways of experiencing digital technology and potential digital affordances appear to be gendered. Because the patterns of these preferences appear clearly in the data concerning lower and upper secondary school students, they are likely to develop during the early years of childhood and youth.

Age, even among young people, has an impact on both digital skills and usage. The importance of age as an independent variable is explained by the increasing versatility of students’ use of digital technology as they grow older. It is the diversity of digital experiences, in particular, that enriches young people's digital skills.

Education appears as the most significant single factor producing differences in young people's digital engagement. Education manifests itself as a categorical social hierarchy as the level of education increases the digital engagement. At the same time, there are significant differences in digital engagement within the same educational level, and digital engagement is generally most likely exhibited by students in the male-dominated fields of education. In particular, genderedness is present in relation to students' views of the ICT as a tempting field of education or profession in the future. As both students’ orientation towards technology and their educational choices are heavily gendered, they reinforce each other and increase gender gaps in relation to digital engagement and potential digital affordances among the future citizens of the information society.

Overall, the current study emphasises the need of sociological scrutinisation in order to understand the importance of digital technology and related social activities in the context of education. The results of this dissertation indicate that gender, age and gendered educational choices determine the digital engagement of young Finns. Digital engagement tends be exhibited by certain individuals as skills and usage are intertwined and mutually reinforcing. It is evident that compound and sequential dimensions distinctively describe the digital engagement of Finnish lower and upper secondary school students. Where comboundness characterises the accumulation of digital engagement for certain individuals, sequentiality increases the likelihood that these individuals will also benefit most from the available digital affordances. In extreme circumstances, sequentiality of digital engagement describes the path to either digital prosperity or exclusion making it an important educational policy issue to be acknowledged in the information society.

Keywords: Digital affordances, digital inequality, education, educational choices, genderedness

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List of original publications

Article I

Kaarakainen, M.-T., Kivinen, O., & Vainio, T. (2018). Performance-based testing for ICT skills assessing: a case study of students and teachers' ICT skills in Finnish schools. *Universal Access in the Information Society, 17*(2), 349–360.
DOI: 10.1007/s10209-017-0553-9

Article II

Kaarakainen, M.-T., Saikkonen, L., & Savela, J. (2018). Information skills of Finnish basic and secondary education students: The role of age, gender, education level, self-efficacy and technology usage. *Nordic Journal of Digital Literacy, 13*(4), 56–72. DOI: 10.18261/issn.1891-943x-2018-04-05

Article III

Kaarakainen, M.-T., Kivinen, A., & Kaarakainen, S.-S. (2017). Differences between the genders in ICT skills for Finnish upper comprehensive school students: Does gender matter? *Seminar.net International Journal of Media, Technology & Lifelong Learning, 13*(2) [online]. Available from: https://journals.hioa.no/index.php/ seminar/article/view/2304/2132

Article IV

Kaarakainen, M.-T., Kaarakainen, S.-S., & Kivinen, A. (2018). Seeking adequate competencies for the Future: Digital skills of Finnish upper secondary school students. *Nordic Journal of Science and Technology Studies, 6*(1), 4–20.
DOI: 10.5324/njsts.v6i1.2520

Article V

Kaarakainen, M.-T. (2019). ICT intentions and digital abilities of future labor market entrants in Finland. *Nordic Journal of Working Life Studies, 9*(2), 105–126.
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1 Introduction

Over the last thirty years, digital technology has reshaped the foundation of industrial production, business and civic participation throughout the world (e.g., Phillips 2016, 1–4; Castells 2012, 4). Along with economic-productive restructuring, a much more profound change has been the digitalisation of social life reshaping the everyday life around digital communication and technology-based infrastructures (Brennen & Kreiss 2014; Castells 2010, 389). According to Jan van Dijk (2012a, 22–23), information society is an apt concept for modern society penetrated by digital technology and characterised by high levels of exchange and use of information. The economy of information society builds on increased information production; most of the workforce is employed in positions that require information processing and the culture of the society is permeated by information products. Furthermore, Manuel Castells (2010, 17) has introduced his concept of informationalisation as a main source of productivity and power, characteristic for the informational mode of development where knowledge itself is the main source of productivity.

According to Christian Fuchs (2011), theories conceiving that the technological development in the last few decades constitutes a radical societal change are so-called discontinuous theories, whereas others stress the continuities of society. The key viewpoint behind the discontinuous information society concepts is that society and the economy have faced a thorough transformation that has given rise to a new society or economy. Regarding the informational aspects, there are subjective theories emphasising individuals and their actions in society and objective theories stressing the importance of social structures. (Fuchs 2011, 77–78.) Discontinuous concepts include a famous assumption that the digital technologies and the Internet appear to produce something more than just a new artefact, a communication channel or a platform; they are expected to provide something exceptional, and that is exactly what is believed to justify their in-depth investigation (Sandvig & Hargittai 2015, 18–19). In the early days of digitalisation, many argued that digital technology implies that “something new, different, and (usually) better is happening” (Woolgar 2002, 3) combined with the “pervasive sense of leaving the past behind” (Murdock 2004, 20). Steven Woolgar (2002, 3) states that the idea of virtual society includes the perception of a wide range of epithetised visions about technologically transformed futures, all suggesting “a major and profound change”. However, as Martin Ford (2015) demonstrates, recently the debate around a more prosperous future has been accompanied with fears of mass unemployment and concerns towards artificial intelligence and algorithms.

Neil Selwyn (2010, 7) accuses both the popular and the academic stance towards digitality for tending “to be informed by a notion that the development of digital technology represents a distinctively new and improved set of social arrangements in relation to preceding ‘pre-digital’ times”. Instead, technological development in Western countries has reached a point where the ubiquitous digital technologies have penetrated our everyday life making the technology invisible. Nearly everything in our daily life at home, at work or at school is digitally transmitted, including the ways how people observe the world, communicate with each other and transact with the public and commercial actors. (Lupton 2015, 2–4.) Thus, the information society does not have a separate ‘desirable virtual’ and ‘old-fashioned real’ existence, but consists only of presence fulfilled with ubiquitous digital technologies.

Along with the spread of digital technologies, researchers from many fields of science have sought to conceptualise skills needed in information society leading to the wide-ranging terminology used to describe these skills (Litt 2013, 613). Technology dominated concepts like information technology (IT), information and communication technology (ICT), or computer literacy became prevalent along with the spread of technologies (e.g., Bawden 2008, 29). Nowadays such concepts as digital competence, digital skills or 21st century digital skills are seen as describing the nature of modern technology and its user requirements more comprehensively (van Laar et al. 2017, 585). It was recently recommended that the concept of digital skills ought to be used when referring to the skills required in the digitalised society (Scheerder, van Deursen & van Dijk 2017, 1614). Consequently, in this study, the term digital skills is seen as providing the apt conceptual tool among alternative concepts for examining these vital competencies in the information society.

In the context of education, the information society and its economy, as well as future skills requirements produced by them, raise important issues to be considered. The knowledge base of the modern information society is build on new ways to produce skills and knowledge. Due to technological development and occupational restructuring, many jobs and entire sectors which are currently considered central for economic growth will no longer exist in the future. The changes in the information society require constant updating of the skills of the workforce, and, in particular, the speed of technological development imposes great demands on competence development. Still, more important than technology itself is the world of international work, where learning and practice will become increasingly blended, not merely because of the changing demands of the labour market, but also because workers themselves need to respond to changing needs. (Teekens 2016, 32.) For van Dijk (2005, 162), information is a positional good; some societal positions offer better opportunities for acquiring digital skills than others making digital engagement increasingly important factor in individuals positioning in the contemporary society. As van Dijk (2005, 144 and 162) stresses, an important feature of digital skills is that the level of inevitable skills for citizens to cope with is constantly rising. In this study this is seen as creating a new kinds of requirements for the education system and exposing individuals to risks of digital exclusion.

The new skill requirements arising from technological innovations have implications to educational policy. A topical example is software competency which has grown in importance in many Western countries due to the restructuring of the ICT industry and the rise of such innovations as cloud technology, artificial intelligence and data analytics. As a result, not only sufficient basic digital skills, but also computational thinking and coding have been assimilated into a set of skills required from the future labour market entrants (e.g., Bocconi et al. 2016, 6). As a consequence, in several countries, computer science has been introduced to primary and secondary school curricula with aims to promote computational and algorithmic thinking, teach problem-solving and basics of programming, and familiarise children and young people with career paths that the STEM (Science, Technology, Engineering, and Mathematics) field professions have to offer (e.g., Hubwieser et al. 2015). Technology skills have even gained the reputation of omnipotency; in the United Kingdom, for example, the metaphor of the "pipeline to prosperity" has been adopted into the governmental policy discourse where it is used to define the economy as a machine that "feeds on a fixed, constant supply of digitally up-skilled youngsters" (Davies & Eynon 2018, 2).

Although there is a common understanding that in order to increase economic competitiveness in the information society, human capital is one of the key strategic resources for success (e.g., Jin & Cho 2015, 259; Livingstone, Papaioannou, del Mar Grandío Pérez & Wijnen 2012, 6; Sahlberg 2006, 259), scholars from the field of sociology of education have a long ago raised critical considerations about technological determinism (e.g., Robins & Webster 1989, 2–5) which has gained a foothold in educational policy and in language related to digital technology. Linda Castañeda and Neil Selwyn (2018) argue that framing digital technologies in education in terms of their association with learning separates the technology from its wider contexts, narrowing its role to a mere learning tool. This kind of vision not only neglects the political, economic and cultural aspects of the technology being used, but also obscures the role of socialisation, subjectification and qualification in education (Castañeda & Selwyn 2018, 2.) Such stance toward technology has had a significant impact on the terminology in the field of education. An illustrative example of this kind of language, obscuring the functions of technologies in education, according to Selwyn (2015, 7), is the talk about learning management systems which in fact support rather the management than learning itself. Similarly, the concept of virtual/personal learning environment in fact incorporates a wide range of features from content production to certification, which in practice mainly support the functions like material production and delivery, and student management. Such inaccurate conceptualisations ignore the profound changes in requirements and opportunities that digital technologies enable in society, labour market and social life. Therefore, in this work, such conceptualisations of digital technologies in education are avoided and they are rather referred to as key enablers or targets for valued skills for citizens of the future.

This dissertation thesis belongs to the field of sociology of education. The reason for choosing the topic of the work originates in Neil Selwyn's and Keri Facer's (2014, 485) notion that despite the invasion of digital technologies into society and all levels of education, researchers of sociology of education have largely been missing from the research and the debate around the matter. Selwyn (2013, 197) argues that sociologists aiming to achieve a comprehensive picture of the dynamic nature of digital technologies in everyday life in the information society have sought it mainly elsewhere than in education. This tendency has been strengthened by the fact that the grand narratives dominating the sociology of education have typically gone a long way round the issues like technology. In fact, while micro-level sociologists in the field have been interested in issues like inequality, resistance, identity and culture describing the processes of educational practices, the macro-level researchers have focused on issues related to social mobility along with the stratification of educational opportunities and outcomes. (Selwyn 2013, 197; Delamont 2000, 96–98.)

As a major consequence, the lack of sociological interest has left the area becoming dominated by education scientists and psychologists, alongside the strong dominance of technology vendors, with the intention to understand the effects and increase the use of technology in learning. Absence of the sociology of education has left much room for technocratic discourses of effectiveness and best practices. These approaches have promoted the individualisation of learning as the engagement with most learning tools mainly necessitates abilities to self-direct one's own learning which is assumed to work in favour of the individual's learning outcomes. (Selwyn & Facer 2014, 485–488.) In this work it is assumed that such individualistic views on the opportunities of digital technology in education are not advantageous for individuals nor for the education system as they ignore both the wide-ranging potentials and the risks of digital technology that go beyond education. For these reasons, this work promotes a broader understanding of digital technology in education, with particular emphasis on the importance of digital skills in students' future life opportunities, rather than the mere use of digital technology in schools.

According to Keri Facer and Ruth Furlong (2010, 451–452), in developed countries the rapid expansion of digital technologies into areas of social, economic, and personal life have made information poverty a key indicator of social exclusion as it refers to being excluded from information loops which connect individuals to, for example, jobs and social networks. As van Dijk (2012b) reminds, in the early stages of the information society, in the time of arrival of the Internet, it was widely assumed that digital technology would enhance digital democracy in the society. Digital technologies, especially the Internet, were seen as an interactive medium that would depart users from one-sided communication of mass media and transform them from viewers to participants, ensuring equal opportunities and acceptance, and promoting collective creation of online products, instead of strengthening the role of corporations. (Van Dijk 2012b, 49.) The actual situation has, however, proved to be more complex than expected; technology has undeniably provided new opportunities, but it has also brought more or less unexpected obstacles to democratisation. Jan van Dijk and Kenneth Hacker (2018, 208–210) emphasise that the question whether the digital technologies do strengthen or weaken democracy is not a binary question, and in fact, at present, no one knows how the story is going to end.

The aspirations of the democratising power of technology are related to the desire to eliminate social exclusion in the information society. Social exclusion is described as a complex and multi-dimensional process involving a lack of resources, rights, goods and/or services (Levitas et al. 2007, 9). Often it is also a question of inability to participate in the normal relationships and activities which are available to the majority of people in the society. All this affects the quality of life of individuals and the equality and cohesion of the society as a whole. Above mentioned definition stresses the idea that social exclusion as a concept is broader than poverty, as it embraces issues of denial of rights and lack of participation. (Saunders, Naidoo & Griffiths 2007, 12.) Social exclusion in the information society has been conceptualised as digital exclusion, divide or inequality. In this study, the term digital inequality is used as it emphasises the relational nature of differences related to digital capabilities. Digital inequality is connected with fast changing environment; the specific feature of digital technology is that it becomes outdated much faster than other technologies or traditional media, which forces users repeatedly to catch up with the latest technology in order to avoid lagging behind technological development and its opportunities (van Dijk & Hacker 2003, 316). This brings a fundamentally new kind of demand for individuals and for the education system. Education should not only provide the skills required for information society, but also make it possible to reflect on what actually happens in the rapidly evolving technological environment and to make agile corresponding changes to curricula in order to adapt to the technological advancement and maintain its relevance as well as prevent the exclusion of the least prepared individuals.

This dissertation thesis examines to what extent social hierarchies, structured by gender, age and education, effect digital engagement among Finnish lower and upper secondary school students and in what ways some individuals come to exhibit more digital engagement than others. The aim of the work is to open and widen the limited discussion about the significance of digital technology in education by elaborating both the demands and opportunities of digital technology to education of citizens for the future information society. In the theoretical part of the study, the aim is to find apt linguistic tools for conceptualising and for further examination of the topic. Chapter 2 focuses on the general expectations toward the digital technologies in education. The goal is not to introduce, and especially not to commit to, any particular learning theory, but rather to look at some current trends in the technologicalisation of education from the perspective of sociology of education. Chapter 2 presents also an alternative perspective to technocratic discourses on the digitalisation of education, by seeing digital technologies through the affordances they provide in education and wider in society. This perspective is important in this work, as one of the key objectives of this dissertation thesis is to promote discussion about the role of education in providing the skills necessary for capitalising the opportunities offered by digital technologies in the social, economic and personal lives of individuals.

In addition to emphasising the perspective of digital affordances, one of the aims of this work is to raise awareness of the importance of digital inequality in education and its negative impact on students' future opportunities in further education, labour market and in life in general. Digital inequality is the theme of Chapter 3 which introduces concepts and central theories, as well as recent empirical evidence of digital inequality. It is examined, in which ways the digital technologies and related capabilities will expose individuals unevenly to various potentially beneficial opportunities. Inequality of the opportunities is manifested as different possibilities to engage with and benefit from technology, in various domains of life, relating to differences in skills and usage. According to Maria Bakardjieva (2006, 74), different kind of engagement with digital technologies, rooted in social relations, creates the meeting point where micro-practices and macro-structures encounter; digital engagement effectuates the individual's action in relation to social arrangements in society determined by patterned relations between social structures, such as socio-economic stratification or social institutions. For this reason, digital usage and the related skills are the main research objects of this study.

When examining the digital skills, this dissertation thesis applies the categorisation of medium- and content-related skills by Jan van Dijk and Alexander van Deursen (2014). This rather robust classification offers an applicable framework to explore these skills over different studies, instruments and changing technological milieu, which has proven to be a challenge for many previous studies in the field due to the conceptual ambiguity. Correspondingly, for the same reason, when focusing on digital usage, Helsper's (2012) classification is utilised, and individual online activities are condensed according to their purpose into economic, cultural, social and personal usage domains. It is commonly thought that digital skills enable the use of digital technologies. In this study, this connection is understood alternatively: digital skills are seen as evolving in digital usage. The difference is, however, largely artificial as digital usage and skills are predominantly intertwined; digital skills have no purpose without usage, as only the intentions of using technology for some purpose make these skills topical and meaningful. The term digital engagement, deliberately instead of participation, is used to describe this inseparability of usage and skills when confronted with technology and the services and communities building on it. Digital engagement, like engagement more generally (see Fredricks 2011, 328), is considered to consist of three dimensions, including behavioural commitment, such as attendance and participation, emotional commitment, such as a positive attitude, and cognitive commitment describing an individual's level of investment in learning the skills needed for particular engagement characterised by self-regulation and strategic behaviour. Engagement is more than mere participation as it bears the potential to transform people.

Chapter 4 draws together the theoretical standpoints of the study and refines the research goal into research questions concerning digital engagement in educational context. The research questions that structure the empirical part of this dissertation are: To what extent gender, age, and educational choices and future educational intentions associate with digital engagement among Finns aged 12–22? And, to what extent and in what ways does digital engagement accumulate among Finnish lower and upper secondary school students? Chapter 5 describes the research processes, the methodology and the data of the five original articles of this dissertation thesis. In these articles, digital technologies provide a platform for collecting and processing the empirical data, but above all, ubiquitous digital technologies are seen as penetrating the social and cultural relationships, which are the actual object of this research. In essence, this work is primarily about human activity in the context of digital technology. Chapter 6 presents the core results of the five original articles from the point of view of the research questions. The research questions are answered individually by combining the key results of the original articles included in this work. Finally, Chapter 7 concludes the work; the results, based on the original articles, will be discussed in relation to prior research and current public debate, as well as the policy implications the results give ground for.

2 Digital Technologies in Education

Varying Expectations for Digital Technologies in Education

Since the 1970s, the benefits of technology-based education have been widely discussed (Kulik, Kulik & Bangert-Drowns 1985; Alpert & Bitzer 1970). Alongside with this debate, the social problems caused by computerisation and automation have also been articulated (e.g., Beynon & Mackay 1988; Ofner 1985). On international level, many global organisations have been highlighting the potential benefits of digital technologies in education, emphasising their impact on global equality, development opportunities and economic growth (e.g., UNESCO 2017; UN 2005; World Bank 2003). For example, in the report of Students, computers and learning by The Organisation for Economic Co-operation and Development (OECD 2015, 124), digital technologies were presented as providers of material, cultural and cognitive resources which promote opportunities for civic participation, networking and improving productivity in work.

In Finland in 2015 the digitalisation of education gained a major role in the strategic program of government (Prime Minister's Office 2015, 18). In this strategic program it was expected that digital learning environments and the new pedagogical approaches they promote would not only nourish the favoured skills and future knowledge base, but also enhance lifelong learning, decrease the dropout rate in education and encourage the equal opportunities and overall renewal of Finnish society. Concurrently, the curriculum reform in both basic and secondary education emphasised the importance of information technology and new media (multi-literacy) skills in Finnish education (FNBE, 2016a; 2016b) which led, for example, to a desire to increase the use of digital devices and learning materials in schools and brought programming to common basic education. The same trends are also visible in the international context, especially in developed Western countries, where teachers have been attracted to accept the digital technology into teaching through the advertising campaigns sponsored by technology vendors and with the support of political actors. Under this influence, on a micro-level, schools have invested in computer-assisted and technology-enhanced learning (e.g., Phillips 2016, 4–6) and more lately in algorithm-driven technologies of personalisation and educational data science (e.g., Williamson 2017a, 105) in order to meet the current expectations and to improve the educational outcomes.

However, education has encountered serious obstacles in harnessing technology as a resource for achieving the desired transformation. According to Selwyn (2013, 202), there have been high expectations about how education is going to change with technology, but the actual change has not been realised. Diana Laurillard (2008, 1) has incisively noted already a decade ago that "education is on the brink of being transformed through learning technologies; however, it has been on that brink for some decades now". The OECD (2015, 3), which firmly believes in the power of digital technology, states that schools all over the world have fallen considerably behind the promise of technology. It has been claimed that there exist a disjuncture between the rhetoric and the reality, and between the policy and the practice in pedagogical use of digital technologies (Phillips 2016, 7). In addition to this disjuncture, Selwyn (2013, 200) claims that the actualised digital reformation of education, promoted by learning technologists, has predominantly implied a reshaping of the educational practices around the individuals without wider transformative power.

Castañeda and Selwyn (2018, 5) argue that one of the adverse factors in contemporary education is the hyper-individualisation of education. Quite often, when aiming to improve participation and achievement rates in education, solutions have been sought from functionalities of technology which enable to customise learning for the needs of an individual learner and from the flexibility of technology that allows the individuals to learn at their own pace, in their own time and from changeable locations. Castañeda and Selwyn (2018, 5) claim that the most prevalent forms of digital technology in education are based on a vision of individual students' responsibility for their own learning and the consequences of their learning-related choices; individuals are expected to become industrious self-improvers, driven by external goals and striving to improve one's own performance. Such ideas of learning are rooted in values of neo-liberalism and surveillance, economic productivity and competitive entrepreneurialism and require increased self-determination, entrepreneurial spirit as well as the ability to self-engage in preferred technology to achieve the educational goals (Kuntz & Petrovic 2018, 68).

Hyper-individualisation in education goes hand in hand with technology-driven commercialisation of education (Castañeda & Selwyn 2018, 6) building on a behaviourist view of learning which implies that human behaviour can be manipulated and adjusted through the design of digital architectures (Williamson 2017c). According to Rob Creasy (2017, 7) such process is likely to reduce the professional expertise of teachers as well as rewarding learning and originality of student's own activity. Technology-led individualisation of learning includes not only opportunities, but also significant risks and burden for individual students as e-learners are assumed to be self-motivated, independent, and diligent workers taking responsibility for their own learning (e.g., Nunes 2006, 133). Although the efforts to improve educational outcomes are based on good intentions, they have enhanced a technology-led personalisation and self-determination of education by means of digitising and datafying education (Williamson 2017b; Selwyn 2013, 200; DfES 2002, 4). Data science approach in education promotes knowledge production and theory generation reflecting the professional mindset typical for the data science. This mindset is not neutral, value-free nor atheoretical; it sees learning in scientific terms emphasising quantifiable, measurable and consequently optimisable nature of human action. (Williamson 2017b, 119.)

Castañeda and Selwyn (2018, 3) warn that pedagogies of technology-based education have often been taken for granted and can not be negotiated. Undoubtedly this is true in many cases because traditional education professionals lack understanding of algorithms that underpin the modern learning systems. Therefore, there is a great danger that this will lead to a situation where there exists an absence of pedagogical insight to the digital technology used in education (Williamson 2017c). According to Williamson (2017c), the fact that education researchers should understand is that numerous issues related to teaching, training, learning and pedagogy, have been outsourced to technology vendors for the sake of the digitalisation of education. As a result, "engineers, data scientists, programmers and algorithm designers are becoming today's most powerful teachers, since they are enabling machines to learn to do things that are radically changing our everyday lives" (Williamson 2017c). A general educational policy atmosphere is in fact implicitly supporting this trend, because, as Williamson (2017b, 119) argues, the power of educational data scientists over the educational field is secured by the fact that these actors are able to provide the data-driven explanations required by a current accent on evidence-based policy.

It is an interesting question to ask, whether there is evidence that technology-enhanced learning has led to positive results or favourable changes in education? In the OECD report (2015, 162), based on PISA 2012 data, it was claimed that there exists only a weak and sometimes negative association between investments in digital technology and students' performance. The same report (OECD 2015, 163) continues, based on both PISA data and the wider research evidence, that the positive effects of technology are at best "limited to certain outcomes, and to certain uses of computers". This confirms Selwyn’s (2013, 202) allegations that no striking change or significant improvement in learning outcomes, commitment to education or equal opportunities has occurred as a consequence of adopting digital technology into education. Therefore, expectations about the liberation of education from time, space, place and material constraints or increasing diversification of learning opportunities due to diffusion of digital technologies seems to have been unfounded so far.

The following paragraphs examines the above-mentioned claims by considering the experiences from Massive Open Online Courses (MOOCs) which are one example of learning innovation that has aroused a great deal of hope for diversifying education and overcoming constraints related to temporal, spatial or material access. Despite the good intentions, it is unclear whether online courses, such as MOOCs, actually provide a solution to these user constraints. At first, most online learning contents present severe accessibility barriers for learners with special needs due to their inept interface design (Sanchez-Gordon & Luján-Mora 2016). This actually poses significant challenges not only for learning but generally for online content, networks and services in all areas of life, which is why the European Commission has set the European Accessibility Act (EC 2015) aimed at reducing barriers for people with disabilities within the area of European Union. In addition, as MOOCs cater for an increasingly internationally audience, they place cognitive barriers on the non-native language users due to the expected high level of proficiency in the course languages (Sanchez-Gordon & Luján-Mora 2015).

The most severe criticism of these learning products, contrary to the ‘education for all’ claims attached to the MOOCs, is that according to previous studies, the users engaging in these kinds of digital learning products are mostly people with already priviledged socio-economic status (e.g., Castaño-Muñoz, Kreijns, Kalz & Punie 2017; Rohs & Ganz 2015; Hansen & Reich 2015). Succeeding in online learning is associated with higher knowledge capital such as strong background knowledge, technical skills, strong reading, writing and typing skills combined with adequate (online) communication abilities (Castaño-Muñoz et al. 2017; Khalil & Ebner 2014). At the same time the influential factors for insufficient performance with digital learning products consist of lack of time and motivation, lack of possibilities to interactivity and related feelings of isolation, but also the hidden costs associated with seemingly free learning products (Khalil & Ebner 2014). Under these circumstances, the kind of self-determination required by selfdirected digital learning is simply too demanding for many individuals, especially for children and young people and those with a low socio-economic background.

In addition to the above-mentioned, as Selwyn (2013, 202) points out, digital technologies seem to have little or no effect on the lack of interest to engage in education as it is primarily associated with non-technological socio-economic issues, such as the employment situation and intergenerational inequalities. It is therefore deceptive to profess that the use of digital technology in education would re-configure issues like non-engagement in education. In fact, high dropout and low engagement rates are a major concern particularly among online courses (e.g., Bozkurt, Akgün-Özbek & Zawacki-Richter 2017, 137). The study conducted by Helen Thornham and Edgar Gómez Cruz (2016) provides another example of the constrains of technology optimism; the use of mobile devices among young NEETs (Not in Education, Employment or Training), contrary to the opposite expectations, has been shown to have failed in empowering marginalised groups. Researchers remind that, like all technology, "mobile phones are not free from sociocultural, political and economic power structures, and any mobility or agency they may offer the user is momentary, contentious, negotiated and ambivalent" (Thornham & Gómez Cruz 2016, 1805).

Peter Stevens, Marious Vryonides and Gary Dworkin (2018, 513) recently listed contemporary issues in education: educational inequalities between social classes and ethnic groups and the impact of the evidence-based accountability movement in education. Race, class and educational opportunities have been the central focus of interests in the sociology of education already for decades (see e.g., Epps 1995). One central phenomenon of education has been the global expansion of higher education, which has not eliminated the significant correlation between low social origin and modest level of education (e.g., Guetto & Vergolini 2017, 1). In many developed countries, gender inequality has not disappeared, but the traditional gap referring to the under-representation of women in education, has transformed to a 'new gender gap' in which the proportion of women in higher education has risen above men in many areas of education (e.g., Klesment & van Bavel 2017). However, on a global scale, gender equality continues to be linked to ethnic and class-based discrimination and human rights in general (Schofer & Meyer 2005; 909 and 916). The diffusion of digital technology in education has not changed these major trends (see Selwyn 2013, 202–203). Instead, it has re-increased their relevance as the digital environment tends to reproduce traditional inequalities and divides as will be discussed in more detail and in a more wider context in Chapter 3.

Affordances of Digital Technology in Education

However, the aforesaid does not mean that digital technology has nothing to give for education. Quite opposite, but the importance of digital technologies for education should be seen from the point of view of what ubiquitous digital technology provides to the students' future opportunities in the realm of lifeworld where all human activity takes place. This leads to face the idea of digital affordances, as it offers a theoretical concept that enables the conceptualisation of the wider meaning and impact of digital technology in education and in individuals' lives. Concept of affordance, by James Gibson (1986; 1977), has been originally used in ecological psychology to assign the latent action opportunities held by the particular environment or situation. For Gibson (1986, 127), affordances "are what it offers the animal, what it provides or furnishes, either for good or ill". According to Gibson the affordances are unique for the subject and should be measured relative to the subject; affordances "have unity relative to the posture and behavior of" the subject being considered (Gibson 1986, 127–128). Affordance are thus a relational property, meaning that they refer to both the environment and the actors involved.

However, among technologists, affordances have been considered as a much more limited concept. Typical for these views is seeing the potential of affordances in a narrow, physical interpretation referring so called low-level or technology based perspective on affordances (see e.g., Bucher & Helmond 2018) which treats affordances as properties of objects. Technology researcher Auke Pols (2012) calls basic visible action potentials, which he assumes being the lowest level of affordances, as manipulation opportunities. As people learn what the effects of their manipulations are, the effect opportunities emerge. The highest level of affordances for Pols are the use opportunities, referring to the possibilities that users can do with artefacts. (Pols 2012, 117–118.) This idea comes closer to the original Gibsonian meaning of affordances. Technology design researcher William Gaver (1996, 114) sees affordances as "primarily facts about action and interaction, not perception". Gaver builds on Gibson's relational model of affordances and argues that affordances are the properties of the environment that are defined in relation to the human interaction within it (Gaver 1991, 80). Thus, for Gaver, the affordances of the technological artefacts are not only visible, but also hidden and possible to detect through experimentation. Affordances do not exist only for individual's action, but also for social interaction (Gaver 1996, 114; 1991, 80). Ian Hutchby (2001, 30) argues that affordance is a concept which rejects both technological determinism and strict social constructivism as it combines the socially constructed and situated nature of digitality with the material constraints of technology.

When considering digital technology in education more broadly than just as a learning tool, a wide-range of digital affordances opens up to education. As Wan Ng (2015) phrases, educational technology for learning, as defined as "consumption of information for conceptual development of subject matter", represent only one available affordance for education. In addition to this limited instrumental affordance, digital technology provides a wide variety of opportunities for education, some of which are discussed below. Multi-modality, referring to the multiple modes of representing the information, allows simultaneous exploration, interpretation and production of information. Tools for information gathering and analysis, understood as tools for research, is an example of a more general affordance as it provides tools and experiences not only for school but also for the outside lifeworld. Similarly, communication, collaboration and sharing are wide-range affordances that cross the limits of school and outside world. Digital content creation and presentation also offer these kinds of wide-ranging affordances. (Ng 2015, 97–121.)

Similarly, in the report of Futurelab (Fisher, Higgins & Loveless 2006, 3) the affordances of digital technology for education were seen as being based on knowledge building, distributed cognition, community and communication, and engagement. Both Futurelab's report and Ng emphasise the opportunities that are associated not only with learning and schooling, but with the broader context of a modern information society. This kind of stance toward digital technology in learning is reminiscent of the discussion within socio-cultural theories which emphasise active and authentic learning in digital learning environments, especially in informal contexts. Participatory learning emphasises that a significant part of learning takes place in collaborative digital environments, as these informal networks take collective responsibility of building accumulative information. (Crook 2008, 31–33; Beer & Burrows 2007, 2.1.) In fact, according to Keri Facer (2006, 1), one of the most potential affordance of digital technology is their power to enhance and expand learning environments within classrooms and beyond schools.

The important affordances of digital technology for education are also the numerous career opportunities it enables. Globally, there is a growing demand particularly for highly skilled workers in the ICT field (e.g., Falk & Biagi 2017a). In fact, digital fluency (Briggs & Makice 2012) is a prerequisite for all fields of economics as evidence indicates a growing demand for digital skills both in and outside the technology field (Berger & Frey 2016, 19). Simultaneously, ICT professions are no longer restricted to traditional IT occupations, such as software, hardware and network related professions, as there are also new professions emerging in various fields related to Internet services, multimedia, e-commerce platforms or so-called user-related software development, such as e-learning, bio-informatics and electronic archiving (Chillas, Marks & Galloway 2015, 2). For example, like Sanna Rimpiläinen, Ciarán Morrison and Laura Rooney (2018, 15) remind, digital health sector is globally one of the fastest growing fields of economics. The prospects for the future labour market entrants enabled by digital technology are therefore more versatile than ever before. Nonetheless, engaging with various digital affordances related to social inclusion and personal enjoyment are often even more important for the overall well-being and participation in digital society than labour market prospects as they provoke types of usage having the most collateral benefits for individuals' lives (van Deursen & Helsper 2018, 2345).

However, opportunities are not limitless or open to everyone. Joshua McVeigh-Schulz and Nancy Baym (2015) proposed the term vernacular affordance referring to ways in which individuals themselves understand affordances they encounter with technology. Affordances exist simultaneously for people at multiple levels of technology (i.e., infrastructure, device, software, feature, etc.) creating the vernacular frame of material structure and practice. Vernacular affordance as a concept stresses the variability of affordances in ways in which different individuals emphasise different aspects of digital action possibilities. (McVeigh-Schulz & Baym 2015, 10–11.) Nina Bonderup Dohn (2009, 163) states that affordances are both dynamic and relational, but also culture-, experience- and skill-related. Building upon the Merleau-Pontian concept of the body schema (see Merleau-Ponty 1962), Bonderup Dohn argues that "affordances are the actionable meanings of objects for a particular agent and as such their existence must be determined relative to the body-schematic space of possible interactions for that agent". Hence, the perceived and enabled affordances in a certain situation for a particular individual are associated with the knowledge, skills and action potential that this individual has acquired through accumulated experiences which have been physiologically, personally and socio-culturally achievable for the individual. Therefore, even in the same technological environment, individuals are not able to engage the same action potentials. (Bonderup Dohn 2009, 163–169.) Bonderup Dohn (2009, 161) emphasises the agency of actors as the affordances of an object are not perceived equally; individuals do not live in a world of their own mentalistic making, but the surrounding world transforms in congruence with what individuals learn to do in it implying an interdependency of the individual and the world.

According to Jenny Davis and James Chouinard (2016, 241), the concept of affordance possess a capacity to recognise technology as efficacious, still rejecting technological determinism. Digital affordances are the link between subjects and objects within digital environment. Davis and Chouinard (2016, 242) propose that artefacts “request, demand, allow, encourage, discourage, and refuse”. They do not appear to everyone in the same way, and neither consistently in every moment of the time: “[w]hat an artifact requests of one user it may demand of another; what the artefact refuses in one moment, it may later allow” (Davis & Chouinard 2016, 245). Davis and Chouinard (2016, 245) argue that the mechanisms of affordances mediate through material and social circumstances by perception, dexterity, and both cultural and institutional legitimacy. This means that the digital affordances vary between individuals depending on awareness of the function, skills and abilities to perform the function in practice, and available social support while execution. For Davis and Chouinard (2016, 245) the digital inequality research serves as an exemplar of this process, as it demonstrates the effects of skills and usage, and the mediating factors which affect the likelihood that artefacts produce (or not) outcomes such as increased competency, accumulated information, and more versatile digital engagement.

3 Inequality in Digital Opportunities

Understanding digital technology in education in a broader sense than just comprehending it as a learning tool, practice or new pedagogy makes it inevitable to confront the issue of digital inequality. According to Christian Fuchs (2009, 46) digital inequality as a concept refers to inequalities in material access, usage capabilities, engagement, and the potential to benefit from information and communication technology. Due to continuous stratification, digital inequalities lead to differences between groups, which, in the extreme, leads to the gainers and losers of the information society (Fuchs 2009, 46). In the early stages of the study on digital inequality, the focus was mainly on inequalities in availability of technology (van Dijk 2005, 49–52; Selwyn 2004, 343–344), drawing a dividing line between those who were connected to information and digital technology and those who were not. The gap between the information haves and have-nots or the computer literate and illiterate is the result of two major divides: divide in access and divide in usage (Bélanger & Carter 2009, 132). Broadly speaking, these kinds of studies are said to represent the first-level digital divide research, primarily interested in material access (e.g., Friemel 2016, 312) and focused on the availability of hardware, software, applications and information networks such as the Internet (Fuchs 2009, 46).

As more people gained access to the technology, their skills and diverse usage became the primary focus of research, as insufficient skills play a major role in digital inequality (van Deursen & van Dijk 2010a, 893–894). This phase became known in the beginning of the 21st century as the second-level digital divide due to being closely related to the differences in abilities to effectively use the medium and engage with online contents despite the spread of relevant technology (Hargittai 2002a). Usage and skills describe the capabilities needed for using digital devices and applications to produce meaningful online content and to engage in online communities (Fuchs 2009, 46). According to Alexander van Deursen and Jan van Dijk (2010a, 908–909), people's Internet skills, in particular, come to determine their positions in the contemporary society, not only in the labour market, but also in social life. The second-level digital divide has therefore been thought to lead to a democratic divide where human interest and skills play important roles, as prerequisites for inclusion and participation in society (Min 2010, 32–33). The second level digital divide is also called the ‘production gap’ when describing the difference between the consumers and the producers of the content on the Internet as inequality in digital production has been said to cause domination by elite voices (Schradie 2011, 145).

More recently, researchers have raised up the issue of a third-level digital divide which concerns the differences in tangible benefits that users gain from using digital technology and the Internet (e.g., Scheerder, van Deursen & van Dijk 2017; van Deursen & Helsper 2015). Research indicates that less privileged people are at risk of being excluded from the benefits of digital technology, such as gaining access to jobs or other economic opportunities, opening possibilities to maintaining their health, and political opportunities like participation or online services. This is a current issue in societies where users have relatively autonomous and unlimited access to both technology and the Internet and display relatively similar profiles of usage and skills. In other words, the question relates to differences in users’ ability to translate their time online into favourable offline outcomes. Research on this third-level divide therefore focuses especially on examining who will benefit the most from the use of the digital technology and in what ways. (Van Deursen & Helsper 2015, 30; van Deursen & van Dijk 2010a, 908–909.)

Two theoretical approaches have strongly contributed to the digital inequality research. The first, the technology deterministic approach, focuses on the diffusion and acceptance of technology, relying on the idea that with the spread of technology digital inequality will eventually disappear or at least be largely mitigated. The spread of technology has been described with the theory of diffusion of innovations (Rogers 1983) known as the explanation for the technologicalisation and for the means by which innovations, products and services are spread and accepted or rejected in societies. The spread of digital technology has also been explained with the technology acceptance model (e.g., Davis 1993; Davis, Bagozzi & Warshaw 1989). In general, while the theory of diffusion of innovations does deal with the process by which a technological innovation is communicated through different channels in the society, the technology acceptance models focus more on individual’s decision-making through which innovations come to be adopted.

Both the diffusion of innovations theory and the acceptance models can be regarded as technology-based approaches leading to a simple dichotomy between the ‘haves’ and ‘have-nots’, in other words, those who have been able to adopt the latest technology and those who have not. Among technology determinists it is widely believed that technological progress will reduce social inequalities and allow more equal participation in society (e.g., Howard, Anderson, Busch & Nafus, 2009, 213). In this way, digital divide is seen as a problem of material access which is caused by bottlenecks in the diffusion of technological innovations and is therefore a temporary issue (Adriani & Becchetti 2003, 18–19).

In this study, the technology deterministic approach described above is considered inadequate and over-simplistic to describe digital inequalities in modern society. Instead, another theoretical perspective, relational approach, is seen as offering more apt theoretical premises and linguistic tools to understand the phenomenon and its implications for the individuals than what is offered by the technology deterministic approach. The relational approach focuses on the association of digital inequality with the different forms of social inequality. From this point of view, digital inequality is not a phasing out phenomenon, as it occurs not only in societies with a low level of spread of digital technology, but also in highly technologically advanced societies. The next section examines the concept and research of the digital divide from the point of view of a relational approach, by looking at the domains and factors of digital inequality, as well as the essential empirical findings.

Relational Approach

Neil Selwyn (2003, 105) argues that the 'natural diffusion' thesis leads to a false assumption, that inequalities are a passing phase of technological adoption. From Selwyn's (2004, 349) point of view, the dismissal of long-term significance of digital divide among technology deterministic approach is dangerous as it ignores the complex relationship between access and usage; the access to technology does not denote the use of it, neither does the use of technology necessarily involve productive or meaningful use. Instead, individuals' engagement with technology is not determined by issues of physical access or adoption, rather it consists of a versatile combination of social, psychological, economic and pragmatic factors (Selwyn 2004, 349). Technology deterministic research deals with digital inequality as if it were binary in nature, differentiating between only two options, one representing negation or opposite to another variable (such as 'haves' and 'have-nots' or 'skilled' and 'unskilled'). Digital inequality is not binary, but originally equivocal, plural, and varied (e.g., Gunkel 2003, 516). Where technological determinism assumes that socio-economic problems can be reduced to technological or availability issues, a relational approach provides a better basis for research for conceptualising and understanding the issue.

Jan van Dijk (2013, 30) reminds that the relational approach enables to differentiate between types of inequality as by drawing attention to the structures producing and maintaining inequalities. Van Dijk adopts Charles Tilly's (1999) definition which describes inequality as unequal distribution of resources in society as a result of the competition between representants of categorical pairs such as male–female, skilled–unskilled or high–low educated producing social closure, exploitation and control. There are two causal mechanisms in behind categorical inequality: exploitation and opportunity hoarding. Despite the constant changes, the categorical pairs reproduce themselves through these mechanisms making inequality a structural feature of all societies. (Tilly, 1999, 7–9.) Moreover, Tilly (1999, 7) adds that "[l]arge, significant inequalities in advantages among human beings correspond mainly to categorical differences ... rather than to individual differences in attributes, propensities, or performances". According to van Dijk (2013, 31), the relational approach does not require describing the priority of categorical pairs in advance because their relative importance is always formed in relation to empirical observations which produce different results for each country, society and societal unit under consideration. In addition, priority in terms of one type of pair does not guarantee the priority in the case of other types of pairs; an individual can simultaneously be on the better side of a digital divide with some of the pairs and stay on the opposite side with the others (van Dijk 2013, 31).

According to van Dijk (2013, 47–48), the relational view of digital inequality stresses the role of skills and usage over physical access, as the former are strategically more important than the latter in contemporary information societies which are built on and linked by social and media networks (e.g., van Dijk 2012a, 31), relying strongly on information as a primary good (van Dijk 2005, 131). In this kind of society, the role of relational differences in possessing and controlling information is becoming increasingly important (van Dijk 2006, 231). It is imperative for information society citizens to be involved with information in at least a certain minimum, and this minimum will increase with the increasing complexity of the information society. To a certain extent, participation above this level leads to, for example, power, productivity, ownership, and identity, and the difference in these beneficial outcomes is the basis for inequality in modern society. Another origin of inequality in the information society is the information itself as it is a source of skills and, together with technology, is related to the uneven capacity of individuals. Thereby, within the labour market, uneven skills of individuals lead to increased knowledge-based divisions. The unequal nature of information is emphasised in van Dijk's thinking as for him information is a positional good; despite the excessive increase in information in society, it is limited in certain circumstances and some societal positions enable better opportunities than others for engaging with valuable information. Thus, possessing particular position in social networks is increasingly dominating the status of an individual in the contemporary society. (Van Dijk 2005, 144 & 162).

Pierre Bourdieu’s theories leaning on methodological relationalism have significantly influenced the language of digital sociologists. According to Gabe Ignatow and Laura Robinson (2017, 962), Bourdieu shifted social sciences toward a relational approach instead of variable-centred hypothesis-testing. They continue (2017, 962) that Bourdieu's ontological attitude combining moderate realism and social constructivism, offers useful conceptual foundation for empirical sociology. Bourdieu's relational sociology combines both objectivistic and subjectivist aspects of social action occurring in a social space by seeing an individual as an actor, without ignoring the structure of society (e.g., Kivinen & Piiroinen 2006, 315–320). For Bourdieu, “the real is the relational” (Bourdieu & Wacquant 1992, 97) emphasising that every distinction is “a relational property existing only in and through its relation with other properties” (Bourdieu 1998, 6).

Bourdieu (1977, 164) argues that individuals adjust their practices and choices according to the social realms. Social space is from Bourdieusian viewpoint a construction of unequally distributed capitals. It is made up of intersecting fields, understood as a network of relations between social positions. Individuals’ practices and choices are linked to the position they possess in society. This positioning is dependent on the overall amount of economic, cultural, social and symbolic capital they hold and the structure of this capital, but also the habitus they live through. Bourdieu’s concept of habitus is constructed by incorporated social habits of the field in question. It refers to the susceptibility of individuals to adjoin with certain types of social life, norms, values and linguistic habits related to their position which generate a system of schemes or tendencies towards the ways of perceiving, thinking, experiencing and feeling. It is both a system of schemes of producing practices and a system of perception and appreciation of practices. (e.g. Bourdieu and Wacquant 1992, 126−127; Bourdieu 1989, 17–19). According to Bourdieu (1989, 19), habitus implies “a sense of one’s place but also a sense of the place of others” and “through habitus, we have a world of common sense, a world that seems self-evident”.

For Ignatow and Robinson (2017, 954), the concept of habitus, in particular, elaborates the applicability of Bourdieu’s work in the field of digital inequality. In her study, Laura Robinson (2009) gives an enlightening example of applying the concept of habitus (in Robinson’s words, information habitus) which plays a key role in defining the ways of online engagement which become habitualised by individuals within particular social context. Two opposite stances towards the technology usage emerge as young people from upper-middle-income families gain more benefits from technology use than their less privileged peers. Privileged young individuals enjoy their leisure time activities and the ‘distance from necessity’ that allows them to engage online in ways of enriching recreation as a form of Bourdieusian ‘serious play’. This enables them to engage in ‘studious leisure’ and further development of playful and exploratory habitus leading to a positive dispositions towards technology as a results of increased skills and positive experiences. In turn, fewer digital resources limit the online engagement of the less-privileged young people who tend to develop a task-oriented information habitus looking for more unambiguous outcomes. This can be described with the concept of the ‘taste for the necessary’, something that Bourdieu sees originating from conditions of scarcity and want. The aspiration to only reach the particular goal prevents them engaging online in more exploratory ways in contrast to their more privileged peers. (Ignatow & Robinson 2017, 954; Robinson 2009, 503–505; Bourdieu 2000; Bourdieu 1984.) This vision successfully illustrates the influence of interaction between individuals' actions and social structures in digital engagement.

According to Ellen Helsper (2017a, 223), research on digital inequalities necessitates even more profound shift toward a contextual and socially comparative approach; not only to theorisation, but also the applied research methods and the planned interventions should recognise the relational nature of inequalities. The dependency between digital exclusion and the ways in which the individual perceives significant others’ attitudes towards usage of digital technology in particular context should be brought to the centre of the consideration. Helsper (2017a) criticises the majority of digital inequality research for its reliance on measuring individuals’ exclusion levels and related socio-demographic characteristics. Such an approach describes the problem of digital inequality individualistically preventing the success of possible interventions because it isolates individuals from their significant social contexts. (Helsper 2017a, 233.) Attention should be paid to individuals' everyday experiences and relationships which determine the relational inequality. The successful interventions require the understanding of individuals’ experiences of their own relational deprivation. It concerns the individuals’ own evaluation of and feelings about the value or acceptability of one’s objective inequality. If an individual is, for example, surrounded by people who do not value the digital engagement, they do not necessarily even see their own disconnection as problematic. Researchers should therefore trace the digital referents and the influence they have on individuals' engagement with digital technology. (Helsper 2017a, 235–237.)

This study leans on the idea that there is no need for explicitly defined or observable limit for sufficient access, competency or online participation, and sees that inequality is determined in relation to other actors, the particular situation and the objectives of desired action. This stance is adopted especially because the relational approach understands inequality through structural aspects of differentiation without falling to exclusively individualistic explanations. Although digital inequality, understood as a relational lack of engagement, is based on unequal resources, it is mediated by behavioural patterns that reflect the general social situation and resources of the individual. From these starting points, the conceptual and empirical viewpoints to digital inequality are discussed in more detail below.

Conceptual and Empirical Viewpoints to Digital Inequality

Leaning on the system theory, Christian Fuchs (2009; 2008) argues that society consists of interconnected subsystems. However, these subsystems are not independent or fulfilling only one specific function, rather they are open, interconnected and networked. According to Fuchs (2008, 62), in order to survive, individuals are forced to tame the nature (ecological subsystem) with technology (technological subsystem) in order to produce resources which can be distributed and consumed (economic subsystem), enabling collective decisions (political subsystem) and constituting values or acquiring skills (cultural subsystem). For Fuchs (2008), economical, political and cultural subsystems build a core of contemporary society. The similar distinction is in fact presented in several traditional sociological theories. Anthony Giddens (1984, 28–34), for example, distinguishes between economic, political, and legal institutions and symbolic orders of discourse as the basic institutions of society. For Pierre Bourdieu's language, economic, political, and cultural capitals form three basic types of structures in society (Bourdieu 1986, 241–252). Jürgen Habermas (1987, 113–118), in turn, conceptualises the corresponding structures as the lifeworld, the economic system and the political systems.

Human agents and the circumstances in which their practices shape the subsystems of society, produce the social structures (Fuchs 2009, 46). Society is primarily an interconnection of social systems in which people enter into social relation with others. In each of these relationships, individuals sense their position towards one another and their practices produce and reproduce certain social structures enabling and constraining individuals' thinking and actions, extending further to other social practices “and so on ad infinitum.“ (Fuchs 2017, 452.) Like social relations, technology also both enables and constrains human practices. This happens through individuals’ material access, abilities to use technology, capabilities to use them in beneficial ways, and through associated institutions (Fuchs 2009, 46). Eszter Hargittai and Yuli Hsieh (2013, 144–147) argue that digital usage and engagement offer potential implications for human capital as a form of academic achievement and financial capital, relevant not only to labour market success, but also for social capital and civic engagement. Therefore, digital divide is associated with an economic divide, a political divide, and a cultural divide as in modern society social structures take the form of accumulated and unevenly distributed capitals (Fuchs 2009, 47). From this perspective, it is basically the multidimensional class structure of the society which causes the structural inequalities.

Laura Robinson (2009, 505) argues that the disparities in digital skills are derived from social stratification in society. Patterns of digital inequality consists of categorical social hierarchies and uneven distribution of resources (see van Dijk 2013, 33; 2012, 61; Fuchs 2009, 46). Social hierarchies emerge from the influence of personal categories such as age and gender, and positional categories such as labour market position and education level. The uneven distribution of digital resources (such as access and capabilities) is another side of the stratification alongside categorical social hierarchies (Fuchs 2009, 46). Uneven distribution of resources originates from the asymmetric distribution of economic, political, and cultural capital manifested as, for example, income, relationships and skills (Hargittai & Hsieh 2013, 129; Fuchs 2009, 46.) For Jan van Dijk (2013, 33) such resources in digital inequality research are: material, referring to possession or income, temporal, referring to time to use technology, mental, referring to ability or motivation, social, referring to supportive network, and cultural, referring to status or preference for being present online. Van Dijk (2005, 129–130) assumes that higher levels of material and mental resources are indeed the factors of digital inequality, but more personal indicators like temporal, cultural, and social resources are even more important aspects.

In the contemporary society, digital inequality manifests itself in economic, cultural, social and personal domains, which are the corresponding domains of traditional (offline) exclusion (van Deursen, Helsper, Eynon & van Dijk 2017, 468). This is based on the Helsper’s (2012) model which focuses on the resources that people possess in their daily lives in the information society (van Deursen &

Helsper 2018, 2337). Helsper's model conceives both social and digital exclusion. The model does not assume that a certain type of engagement would defeat another or that more frequent use necessarily would mean deeper digital inclusion. Depending on individual's offline conditions, digital exclusion from a particular type of online engagement can be linked to more or less disadvantage in individual's daily life. (Helsper 2012, 405.) The four key domains (economic, cultural, social, and personal) of corresponding online resources, are based on empirical research and, for instance, Bourdieusian theorisation and van Dijk's (2013; 2005) conception of resources (van Deursen et al. 2017, 454). According to Helsper (2012, 404), economic online resources refers to commercial and information -related uses and learning via digital resources which increase abilities to gain benefits like income or savings, improvement in employment status or finances, and better educational grades or degrees. These resources can be operationalised by engaging in online shopping or banking, distance learning or online information seeking. Bourdieu (1986, 16–17) saw education as a part of cultural capital referring it to objectified and institutionalised form of qualifications providing status in society. However, for Helsper (2012) and van Deursen et al. (2017, 454) education is a part of economic capital, because it is a resource that gives the opportunity to acquire more income, better jobs, and increased wealth.

Cultural resources refers to gender, ethnicity, and religion, but also creative and productive activities related to participatory cultures (see e.g., Jenkins et al. 2009). Cultural usage produce outcomes associated with identity and belonging (van Deursen & Helsper 2018, 2336; Helsper 2012, 414). Personal resources emphasise personality, aptitudes, and well-being, and are related to entertainment and leisure, self-actualisation, and health-related online engagement. Personal resources can be measured as interests (leisure or hobbies), intelligence, and both psychological (confidence) and physical (health) well-being. The resources in the social domain relate to connections to networks which provide attention and social support from other people. These can be operationalised as family ties, networks build on common interests, group membership, voting, power within the community, and influence over unknown others. Therefore, civic and political participation are also included in the social domain of resources in this model. (Van Deursen et al. 2017, 454–455; van Deursen & Helsper 2018, 2336; Helsper 2012, 414.) Helsper (2012, 412) argues that access, skills, and positive attitudes toward digital technology and the Internet are important but not a sufficient condition of beneficial use. The most important are the ways in which individuals engage with technology. Albeit, the four domains of digital resources belong to separate scales, they are interrelated (Helsper 2012, 414). The model sees the actor him- or herself as a locus of capital and as a player in different (sometimes overlapping) fields, instead of focusing on the social structure of the fields in which online resources are activated (van Deursen & Helsper 2018, 2337). For Helsper (2012, 405) the digital inclusion is embedded in an individual's offline circumstances, and therefore digital exclusion should be analysed in connection with social exclusion.

In empirical studies, social status has been found to relate to different types of profitable technology usage (e.g., Hargittai & Hinnant 2008; DiMaggio, Hargittai, Celeste & Shafer 2002) and individuals who are already in privileged positions in the society are identified as gaining more benefits of their technology use than disadvantaged individuals (Zillien & Hargittai 2009, 287). Studies examining digital inequality in countries where the Internet and digital technology are highly available indicate that education, gender and age are the most crucial factors for individuals' digital inclusion (e.g., Hatlevik, Scherer & Christophersen 2017; Hargittai & Shaw 2015; van Deursen & van Dijk 2014; van Deursen, van Dijk & Peters 2011; Helsper & Eynon 2010) whereas, for example, income and residency (e.g., van Deursen & van Dijk 2014), Internet experience and the number of hours spent online (van Deursen et al. 2011) are less relevant for inclusion. Therefore, empirical evidence pertaining to digital skills and usage in association with gender, age and education is introduced in more detail below.

Gender Gap

In Europe, gender inequalities in access, skills, and usage, but especially in digital education and digital labour market have long been at the centre of political concerns (see e.g., EIGE 2016). At European level, the traditional access divide still emerges between nations and overall Internet access of EU households ranges from 57% in Bulgaria to 96% in the Netherlands (EIGE 2016, 5). In Finland, based on official statistics from year 2017 (OSF 2017) and PISA 2012 results (OECD 2015, 36), the proportion of individuals using the Internet is 100% among young people aged 15 to 34, which indicates that, at least among young Finns, there is no divide in terms of access to the Internet between genders. As disparities have decreased in material availability, at least in highly technologised countries, the gender gap has been identified as being linked to the differences in digital skills and usage. Empirical evidence of gender difference in digital skills has proved to be quite contradictory and consistent results are missing. While previous studies based on performance tests suggest that there are no gender differences (van Deursen & van Dijk 2010a), others show females to be more successful than males (e.g., Aesaert & van Braak 2015) and still some others vice versa (e.g., Correa 2016, 2010; van Deursen & van Dijk 2015; van Dijk 2013; 2012b; Fuchs 2009).

What comes to usage, a previous study on young people (Tondeur, Van de Velde, Vermeens & Van Houtte 2016) shows that, generally speaking, females tend to be less positive toward digital technology, but nevertheless attitudes towards using technology for educational purposes are not affected by gender. This indicates that female's interest in using technology is influenced by its utility (Tondeur et al. 2016, 69). Females engage with more restricted range of online activities and participate less than males particularly in conversations or user-generated content platforms or sharing content online (Correa 2016, 2010; Hargittai & Jennrich 2016; Hargittai & Shaw 2015; van Deursen & van Dijk 2014; Hargittai & Walejko 2008). According to Teresa Correa (2010, 85), the gender differences in digital technology usage are influenced by psychological factors such as lower levels of confidence and weak motivation. In a study concerning social media usage and skills, digital skills did not associate with frequency of usage, which was, instead, influenced by other socio-economic factors such as education (Correa 2016). Thomas Friemel (2016) shows that gender differences in technology usage disappear among elderly people when controlled for education, income, technical interest, pre-retirement, computer use and marital status. Friemel (2016, 325–326) concludes that the social context affects Internet use and the usage is not simply a gendered issue.

The significance of gender differences in digital skills and usage is in the far-reaching consequences. As the report of European Parliament (EP 2018, 19) shows, women tend to avoid ICT related studies and digital careers; only about 32% of ICT field employees are women. Because of the strong growth and demand for workforce, improving women's digital skills is deemed desirable. It would strengthen their inclusion in the ICT workforce, which would increase both female's employment and decrease the labour shortage in the ICT field. In addition, as the ICT field is known as a high paying sector, women's inclusion in the field is expected to reduce the gender pay gap as well. (EP 2018, 20.) The reasons for a small number of females in the field of ICT are assumed to be rooted in long-held stereotypes related to teachers' and parents' tendency to encourage particularly boys toward technology combined with the lack of female role models, misconceptions on girls' aptitudes, organisational constraints and the lack of work-life balance at work (Cheryan, Ziegler, Montoy & Jiang 2017; EP 2012, 7–8.) Van Dijk (2005) claims that gender differences in the adoption of technology evolve early in life; while little boys pick up technical toys and devices, girls usually choose to play with other toys. This triggers a reinforcement process where girls avoid learning technical skills whereas boys build up cumulative technical abilities. In adulthood this allows men to grasp technically and strategically important job opportunities and have an advantage over women in the field. (Van Dijk 2005, 11–12.) This quite rough generalisation brings together familiar assumptions that gender preferences are reproduced through socialisation that takes place in families and education during the years of early childhood and adolescence.

The PISA results provide an important reminder of the impact of attitudes and interests on technology orientation. Based on these results, young Finnish people are relatively passive in engaging with science-related activities outside of school. Especially Finnish girls do not show strong interest in these topics. (OECD 2016, 119–120.) However, Finland is the only country in included PISA 2015 study in which girls are as more likely to be among the top performers in science instead of boys (OECD 2016, 17). Despite girls' success in science, career prospects for the future are indicated as being particularly traditional among Finnish 15-year-olds; boys were over four times more likely than girls to expect a science-related career as an engineer, scientist or architect while Finnish girls were more than three times more likely than boys to expect a career as a healthcare professionals (OECD 2016, 117). This is in concordance with research evidence indicating that in advanced industrial societies, dispositions toward mathematics or technology tend to be more male dominant. Therefore, the gender segregation of educational fields and labour market tend to reinforce the existing gender stereotypes especially in developed countries (e.g., Charles & Bradley 2009, 960.)

Age Divide

A popular assumption is that the digital skills of younger users are superior to skills of older adults. There are, of course, several studies that support this assumption. For example, van Deursen and van Dijk (2011, 905) found that older age decreased technical competency, namely basic skills in using technology and navigating the Internet, but this did not influence to the level of accessed information nor their strategic skills. Based on more recent results of van Deursen and van Dijk (2015, 388), age appears to have a strong effect on material access and medium-related digital skills, but only a minor effect on content-related skills and diversity of usage. Based on the results of PIAAC (OECD 2016), young adults (ages 16 to 24) in Finland are more proficient in technology-related problem-solving than rest of the Finnish adult population. However, overall, the evidence on the association between age and skills is not clear cut. For example, based on the results of Eszter Hargittai (2010, 92), the digital skills of young people vary and young people are not universally savvy with digital technology. Moreover, according to Eszter Hargittai and Kerry Dobransky (2017, 207), the skills of older adults are also much more diverse than expected and not all elderly people suffer from poor digital abilities.

In the comparative study of the variance in technology usage in five highly developed countries (New Zealand, Sweden, the United States, Switzerland, and the United Kingdom), it was found that social interaction and entertainment related online activities decline with age, whereas the decline is less pronounced in information seeking and commercial transactions (Büchi, Just & Latzer 2015, 2715). In fact, most of the variation of the social interaction was explained by age, as young people (under 16 years) engage in social interaction-related activities much more than older groups (Büchi et al. 2015, 2715). The same kind of observation is made in the study conducted by van Deursen and van Dijk (2014, 516), the most prominent variable causing differences in Internet usage being age, the youngest age group (16–29) being more active in every usage factor than the older participants. However, according to Hargittai and Dobransky (2017, 195), when skills are controlled, older adults with higher socio-economic status are more likely to engage with diverse types of capital-enriching online activities. Therefore, despite the correlation between age and use, age as a single variable may not be sufficient to explain the differences in the online engagement of individuals.

The age divide is usually understood as a transient phenomenon; the digitalisation of everyday life requires digital skills from every adult so that they are able to run their daily affairs and are successful at work. Due to this, the weak technological skills of older generations are considered as a generational issue, which is assumed to disappear as older non-users pass away (e.g., Wagner, Hassanein & Head 2010; Gilleard & Higgs 2008). However, among elderly people, the digital inequality is not just an age issue. Friemel (2016) shows that many senior citizens are not using the Internet due to disabilities such as limited eyesight or hearing. In these cases, the real cause of digital inequality is the loss of the ability to use technology, even if the same individuals have previously been active online participants. (Friemel 2016, 325.) Therefore, overcoming these disability issues requires technological development, such as improved usability, which eliminates common age-related barriers affecting senior' technology usage (Lee, Chen & Hewitt 2011, 1236), as opposed to merely waiting for these problems disappearing on their own, as the older generations are gradually replaced by a new, more technological savvy generation of people.

More evidence on this issue, that digital inequality is not a transient age group concern, comes from Sweden. The study of Ellen Helsper and Bianca Reisdorf (2017, 1265) demonstrates that in Swedish society, digital exclusion is attached to the most vulnerable individuals, as social exclusion and economic disadvantage have become the main predictors of digital exclusion. This is interpreted as a sign of the emergence of a digital underclass. Therefore, Helsper and Reisdorf (2017) warn that despite the early experiences of younger generations with digital technology and the Internet, the next few generations in Sweden will include a small but severely excluded group of individuals which will be relatively more marginalised than those in the current generations and the problem of digital exclusion will revolve even more around the most socially vulnerable individuals than it does today.

Educational Polarisation

As mentioned already, the relationship between digital skills and socio-economic status, most typically dominated by the level of education, has been recognised in several empirical studies. In studying sample of 18 to 29 -year-olds, Correa (2016) detected that digital skills increase with the level of education. Similarly, based on the results of Hargittai and Dobransky (2017, 207), the skills of older adults are also strongly associated with education, as higher education level and income are associated with higher levels of digital skills among elderly people. In fact, according to van Deursen and van Dijk (2015, 387), education influences not only digital skills, but also the diversity of usage of digital technology. This increases the importance of education for digital engagement.

When examining the relationship between education and usage, the research evidence demonstrates that lower educated individuals tend to use the Internet more frequently than their higher educated counterparts (Tsetsi & Rains 2017; Correa 2016; van Deursen & van Dijk 2014). This is due to the fact that less educated people prefer such forms of digital usage that take a lot of time. For example, van Deursen and van Dijk (2014) noted that higher educated participants use digital technology in more beneficial ways; individuals with medium or high levels of education, in particular, use the Internet more for participating together with usage related to information, news and personal development, whereas individuals with low level of education engage more often with gaming and social interaction, which both are seen as time-consuming digital activities. (Van Deursen & van Dijk 2014, 520–521.)

According to Correa (2016), although the frequency of usage of lower educated individuals is high, they consume less information and news and produce less mobilising information online, all of which have been said to produce more meaningful user outcomes. Lower educated young people in particular tend to use social media more frequently than others. (Correa 2016, 1102–1104.) According to Eric Tsetsi and Stephen Rains (2017, 251–251), low levels of education, along with some other disadvantageous socio-economic factors, tends to be associated with smartphone-dependency which refers to the situation where individual’s only means of accessing the Internet is via a smartphone. As smartphone-dependency tends to reduce the versatility of Internet usage, it threatens to limit individuals potential for engaging beneficial online activities.

In summary, the effect of education level on digital engagement is evidently significant. Van Deursen and van Dijk (2014, 521) assume that the variation in digital skills and usage habits produced by differences in education levels are more evident than differences produced by age and gender. This makes these differences also relatively permanent. Particularly in the domains such as economic commerce, institutional government, and educational outcomes the empirical evidence indicates that higher educated people gain more benefits from digital usage than their lower educated counterparts. In this way, despite the fact that more and more people have gained access to digital technology and the Internet, the use of technology offers the most to the higher socio-economic groups. (van Deursen & Helsper 2015, 46–47.) Therefore, it is important to study the link between education and digital inequality and to seek to refine the results obtained in previous studies in order to provide a better understanding of the phenomenon.

4 Research Questions

In this study, the digital technology in education is seen primarily through digital affordances which open up chances for individuals in education and more wider in life. Due to the fact that affordances are not similarly open to everyone, it is important to consider digital inequality as a relational issue relating to individual' abilities to make use of these affordances. Therefore, this inequality is the actual object of the empirical part of this study. According to Helsper (2012, 412), access, skills, and positive attitudes toward digital technology and the Internet are important, but not a sufficient conditions of beneficial use. The most important factor is the way in which individuals engage with technology, operationalised as the types and levels of usage. Here digital inequality is understood as an intertwined combination of inequalities in digital skills and usage, and a certain type of engagement is expected to lead to more profitable activities that are more likely to expose individuals to potentially beneficial outcomes, while others do not. However, in order to explore digital engagement, it is important to analyse its components and therefore focus on examining digital skills and digital usage.

This dissertation thesis seeks to increase understanding about digital inequality among young people in context of education in Finland by scrutinising the differences in digital engagement of the Finns aged 12–22 by combining the results of five original articles. The work aims to identify social hierarchies producing unequal distribution of skills and usage among young Finns. The articles included in this dissertation focus on the variables that, based on previous research (see e.g., van Deursen & van Dijk 2014), most strongly divide digital inequality, namely gender, age and education. In the case of education, the focus is not only on education levels, but also on educational stratification known as horizontal segregation which refers to the unequal distribution of education in a way that is not hierarchical. Hierarchical segregation, also known as vertical segregation, refers to the unequal positioning of genders in the occupational hierarchies, leading to differences in prestige and income levels (e.g., Charles 2003, 270; Blackburn, Jarman & Brooks 2000, 129). In comparison, horizontal segregation refers to the tendency of men and women to orientate in gender-specific occupations within the same level of education (e.g., Triventi, Skopek, Kosyakova, Buchholz & Blossfeld 2015, 31; Charles & Bradley 2009, 930).

Occupational specificity, which is typical of education systems which are divided into vocational and general education, links education and occupations strongly together and increases the likelihood of horizontal gender segregation (Triventi et al. 2015, 33). For this reason, it can be assumed that there occurs considerable horizontal segregation also in Finland, where there is a wide-scale vocational training option alongside general upper secondary education. The horizontal segregation is, at least to some extent, said to be rooted in stereotypical beliefs that tasks involving personal service, nurturance or interpersonal interaction are more suited to females, whereas tasks involving strenuousness, physicality and interaction with things are more prototypical for men (e.g., Charles 2003, 269). Maria Charles and Karen Bradley (2009, 930 and 959) have reminded that this kind of segregation is in fact more pronounced in advanced industrial societies than in developing countries, where educational choices have a more crucial role for individuals' economic success and overall survival for both genders.

The study also investigates the ways certain individuals come to have high level digital skills and to exhibit high levels of profitable usage. To be more specific, to pose this in a form of question, this study asks to what extent digital engagement among Finnish students has a compound and sequential nature? According to van Deursen et al. (2017, 468), compound exclusion refers to a cumulative disadvantage, i.e. that the lack of a particular skill will also likely lead to the lack of other skills and a lack of participation in some areas also likely results in a lack of involvement in other areas. The sequential exclusion, in turn, refers to the dependency between different types of digital exclusion: lower level of digital skills are associated with lower level of digital usage, resulting in a fewer chances for beneficial outcomes. However, it should be noted that individuals achieving benefits in one domain do not necessarily gain positive outcomes in another. (Van Deursen et al. 2017, 453 & 468.)

Compoundness and sequentiality are important aspects to examine as they promote understanding of the features of digital inequality and the functions through which it affects individuals. Thereby concepts of compoundness and sequentiality of digital inequality contribute to a reaching adequate understanding for apt interventions in education.

The five original articles included in this dissertation thesis deal with above-mentioned central themes giving comprehensive understanding of digital engagement among Finnish lower and upper secondary school students. The research questions structuring the empirical part of this dissertation are as follows:

1) To what extent gender makes a difference in students' digital engagement in Finnish lower and upper secondary schools?

2) How does the age of Finnish upper secondary school students affect their digital engagement?

3) How are gender-segregated fields of education and future intentions associated with digital engagement of 12–22 -year-old Finns?

4) To what extent and in what ways does digital engagement accumulate, as exhibited by certain individuals more than others among Finnish lower and upper secondary school students?

5 Research Methodology

The Measurements

Various methods have been used to study the skills required for digital technology and the Internet. Eden Litt (2013, 615–617) has classified such assessment methods into survey/self-report measures, performance/observation measures, and combined/unique assessments. Surveys and self-reports have been the most dominant methods for quantitative studies assessing digital skills. In self-assessments participants have to respond to a question or a set of questions about their own competence levels or evaluate their ability to perform specific tasks on the Internet (e.g., Bunz 2009). According to Litt (2013, 618), the qualitative studies have preferred observation-based measures or interviews, which incorporate ethnographic practices. These types of studies focus on, for example, observing a person's actions during information search tasks (e.g., Kiili, Laurinen & Marttunen 2008). Interviews, in turn, typically consist of open-ended questions like what online services people use, what type of sites they visit, and whether they feel their skills are adequate (e.g., Smith & Caruso 109–110), whereas performance-based online tests consist of practical tasks related to the use of digital technology, applications and the Internet, and their utilisation in various practical situations (e.g., Aesaert & van Braak 2015).

Self-assessment surveys have been criticised for significant validity problems (e.g., van Deursen, Helsper & Eynon 2016, 804–805; van Deursen & van Dijk 2010b, 892; Hargittai 2005, 376), conceptual ambiguity and over-simplification of the phenomenon in question (van Deursen et al. 2016, 804). The problematic nature of self-assessments is related to the tendency of over- or under-estimating one's own knowledge (e.g., Porat, Blau & Barak 2018, 23; McCourt Larres, Ballantine & Whittington 2010, 97) and how biased estimations are more common among males (e.g., Hargittai & Shafer 2006, 444). The main problems of performance-based tests are their time consuming nature and high development costs. They are also more difficult to replicate and utilise in studies investigating large samples. (Aesaert & van Braak 2015, 9; Litt 2013, 618–619.) On the other hand, in several studies, two or more types of measures are combined which, according to Hargittai (2002b, 1243), lead to rich data allowing the examination of not only diverse usage and skills, but also the underlying social factors. In this way it is possible to reduce the limitations of methods.

An important developmental aim was to create a test application for large samples. One of the key ideas of the test development work has also been to overcome the problems of self-assessment to achieve more objective results. These needs lead to the development of the ICT Skill Test in the Research Unit for Sociology of Education, University of Turku. The author of this dissertation thesis has been responsible for the development work covering both the technical and the content development of the test. The test was developed in two phases; the original test in 2013 and the renewed test in 2016. Due to the curriculum reform in basic education (FNBE 2016a), substantial changes had to be made to the test contents in year 2016. Furthermore, further adjustments were made to the test contents based on the experiences gained during the pilot stage of the original test. The development of the second version was assisted by a steering group (related to the project funding which enabled the second sample of this dissertation) led by the Finnish Ministry of Education and Culture. The steering group provided feedback on test contents, particularly in relation to the curriculum objectives of the renewed curricula for information and communication technology learning goals in basic education.

The ease of use, reliability, scalability and automation of routine administrative tasks have been the key objectives for the test instrument that combines a performance-based test with a more traditional online survey. The implemented test application is a web application, written in PHP and JavaScript programming languages together with TinyMVC- and Bootstrap-frameworks. The application utilises PostgreSQL/MariaDB databases for data storage needs. The application is bilingual as Finnish and Swedish are official languages of Finland. The test application contains four kinds of user roles: student, teacher, organisation, and administrator. Each of these roles has a different set of actions and views available. Data protection issues were addressed with diligence due to the enactment of General Data Protection regulation ((EU) 2016/679) which became applicable as of May 25th, 2018. For example, in the case of the student-role, no login was required (no directly identifiable personal data was collected from minors) and at the beginning of the test, data subject’s consent for research was requested (the data subject was able to withdraw the consent at any time during the test session). In addition, when the test was done and the user closed the test, all the test data was gathered into a separate research database, and deleted from the application's database which was used for data storage only while the test session was active.

In development work the key aspect has been to separate the test contents from the technical test environment and the types of tasks it enables. This allows the use of the same application in different studies by simply changing the content. That is why the test content (tasks and the specific surveys in each study) were included in the test application as easily changeable Extensible Markup Language (XML) files. In this particular research, the contents of the test instrument were closely related to the curricula objectives of basic and secondary education especially due to the curricula renewal in year 2014 which brought digital skills to a more prominent role in education in Finland. The test contents utilised in this study are therefore based mainly on the definitions and goals of ICT competencies of the Finnish national core curriculum for basic education (see FNBE 2016a; 2004).

The original ICT Skill Test was developed mainly on the basis of the year 2004 Finnish National core curriculum for basic education (FNBE 2004). In this previous core curriculum the objectives were to offer understanding of technology and its evolution and impact, to use technology responsibly and to learn to use equipment, programs and networks (FNBE 2004, 41). Information technology was also one of the optional subjects which students could choose to participate during the last two grades (FNBE 2004, 254). In turn, the renewed ICT Skill Test is based on the renewed national core curriculum where ICT competence is one of the seven transversal competence studies integrated into all subjects. In the renewed curriculum ICT competence is considered to be an essential factor of civic competence and is seen both as an object and an instrument of learning. In practice, the goal is to offer understanding of the basic operations and concepts of ICT, knowledge to use ICT in a responsible, safe and ergonomic manner and skills to use ICT as a tool in information management, creative work, social communication and networking. (FNBE 2016a, 24.) In secondary education, the curricula were reformed at the same time, and, in general upper secondary schools in particular, the renewed objectives are in line with the goals of basic education and strives to strengthen the knowledge produced by the previous educational level (FNBE 2016b).

The 17 test items in the original ICT Skill Test were classified with factor analysis (Article I) to basic digital skills (word processing, spreadsheet, social networking, information seeking, presentation, basic use of computers, image processing, and web content creation), advanced technical skills (operating system installation and initialisation, maintenance and updating, software installation and initialisation, information security, and information networks) and professional

ICT skills (server environments, database operations, digital technology, and programming). As already mentioned in the introductory chapter, this study utilises a framework of digital skills, where the skills are divided into medium- and content-related skills because it helps to overcome the problems of the operationalisation differences of the different test versions, at least to some extent. Van Dijk and van Deursen (2014) divide digital skills into operational skills, formal skills, information skills, communication skills, content creation skills, and strategic skills. Furthermore, van Dijk and van Deursen (2014, 6–7) separate medium-related digital skills which concern the technical aspects (i.e., operational and formal skills) and content-related digital skills (i.e., information, communication, content creation, and strategic skills) concerning the substances.

In the case of the 18 items of the renewed ICT Skill Test, the following items were classified as medium-related skills: basic operations, information networks, installations and updates, and functionalities of word processing, spreadsheet, and presentation software. In turn, the following items were seen as content-related skills: information seeking, communication, video- and audio processing, cloud services and publishing, image processing, social networking, information security, and software purchasing. In addition, because the renewed curricula in Finnish basic education includes also programming, the renewed ICT Skill Test also measures four kinds of programming related sub-skills: elementary programming, database operations, web programming and programming which, however, were only briefly examined in the fifth article. Since the purpose of the both versions of the ICT Skill Test is to measure participants' digital skills, their content deals with educational and partly psychological testing and therefore requires validation through the methods used in these sciences. Classical item analysis relays on test level statistics which are targeted to measure the quality of the test (i.e., reliability and validity) and the item level statistic (e.g., item difficulty and discrimination power) (e.g., Kaplan & Saccuzzo 2017, 135–146 and 173–186; Considine, Botti & Thomas 2005, 21–23.) The contents of the both test versions together with the estimates of their reliability and validity measures are attached to this dissertation (Appendixes 1 and 3), but they are also covered and discussed in original articles.

Between the two core curricula (FNBE 2004 and FNBE 2016a), there can be seen a clear shift from medium-related skills or computer literacy to the broader importance of citizens' information society skills and concept of digital competence. Thereby also the characteristics of the ICT Skill Test changed as it was transformed from a more technically oriented test into a tool that provides a much broader view of digital skills. In agreement with Fazilat Siddiq et al. (2016, 78), even though some kind of core digital competencies may stay relatively stable over time, the content of these competencies and the environment in which they are utilised is undergoing changes due to rapid technological innovations. In fact, operationalisation of digital skills change over time due to technological advances and changes in the availability of technology (e.g., Erstad 2006). These changes force the assessment instruments to be based on continuous development (concerning both, content and their technical implementation) when aiming to meet the requirements of the fast changing technological milieu. For this reason, alongside the test content renewal, also the test application experienced a thorough change in year 2016; the overhaul of the test application included modern responsive and accessible user interface and an extension of the possibilities for interaction. Technical reforms are necessary from time to time in order to keep the test instruments up to date and to avoid distorting the results, for example due to an obsolete user interface or difficulty of use.

The ICT Skill Test was developed to enable sample-specific surveys. The application presents these survey questions to the participants at the beginning of the test immediately after the study description and the consent form. For purposes of this research, both test versions consisted of background variable and technology usage habits questionnaires. In the original ICT test the background variables included: gender, age, education level, and whether the secondary education level student was studying in a general or a vocational upper secondary school. The technology usage habit questionnaire collected information about how frequently the participants used different kinds of digital devices and how frequently they used digital technology for different purposes. The renewed ICT Skill Test collected participants' age, gender and education level, but also current educational choices (general upper secondary school or vocational institution, whether the student was a general upper secondary school student participating in a basic or advanced syllabus in mathematics, and if the test-taker came from a vocational upper secondary school, participant's field of education), and the participants' future intentions, i.e. the field in which they desired to study or work after graduating from their current education.

Similarly to the original test, the renewed test's usage habit survey gathered information about how frequently the students used different kinds of digital devices and how frequently they were used for different purposes. However, in a newer version of the test the usage habit survey is shortened as it was not originally intended to examine individual online activities, as opposed to more general purposes of use. Responses of both usage habit surveys in both test versions were categorised according to Helsper's (2012) classification, whereby different types of digital usage are classified as economic, cultural, social and personal use. The contents of the surveys and their classification for usage domains are attached to this dissertation (Appendixes 2 and 4).

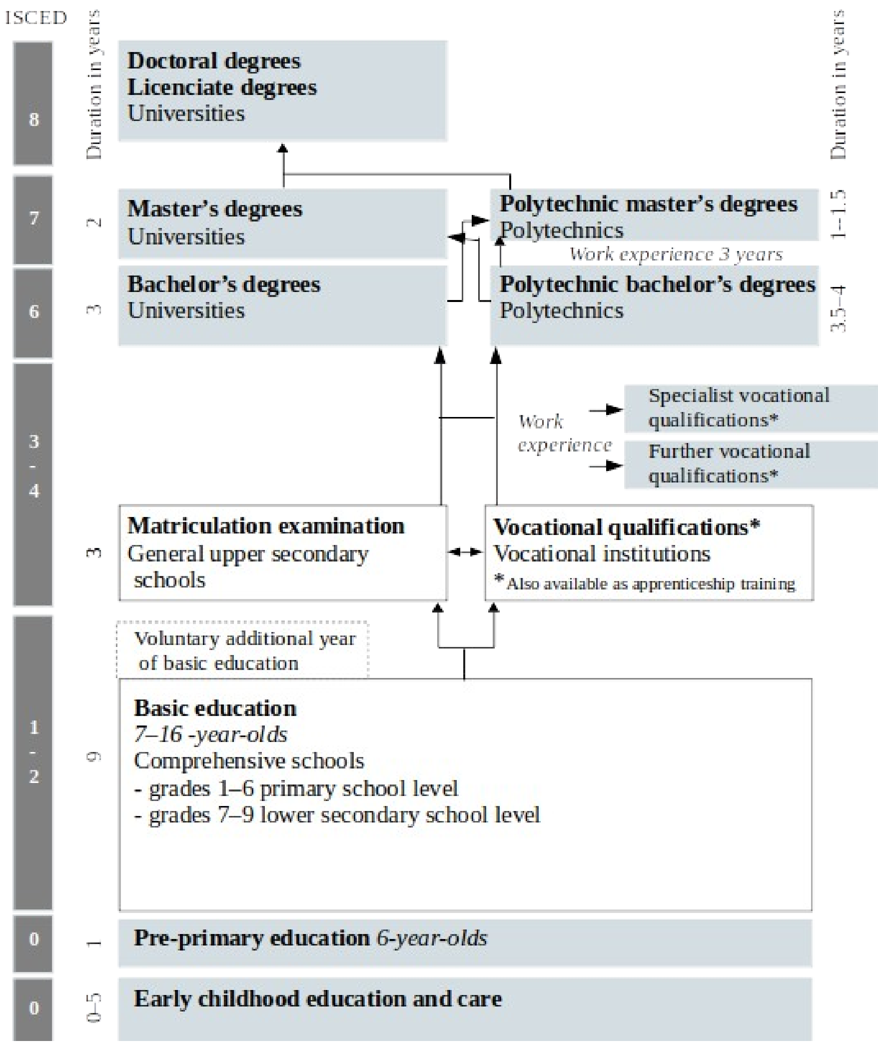

Figure 1. The Education System in Finland with the ISCED Classification and Duration in Years (MEC & FNBE 2017, 3).

Figure 1 represents the Finnish education system in relation to the international standard classification of education (ISCED) which is maintained by the United

Nations Educational, Scientific and Cultural Organisation (UNESCO). This study focuses on the parts of the education system described in the figure on a white background. At basic education level, this study focuses on grades 7–9, the so called lower secondary school level. At secondary level, the study covers both general and vocational upper secondary schools. In Finland, after common nine year basic education, over 90 per cent of each age group starts general or vocational upper secondary education, both of which give students eligibility to continue to higher education level (MEC & FNBE 2017, 17). In general, approximately half of the age group continues in general upper secondary education in Finland, although the number of general upper secondary school students has fallen in the 2000s due to the declining size of the age group and an increase in the attractiveness of vocational education options (FNBE 2018, 11).

The educational level in this study is defined in accordance with the ISCED 2011 classification. The 7th to 9th grade students are on the lower secondary level of Finnish basic education, i.e. on the second stage of basic education (ISCED level 2). The general and vocational upper secondary school students are on the upper secondary level (ISCED level 3) (UIS 2012). In the case of vocational upper secondary school students the fields of education are defined as the fields of study for which the vocational qualifications are classified in Finland, consisting the following eight fields: culture, natural sciences (ICT), natural resources and environment, tourism, catering and domestic service, social services, health and sports, technology, communication and transport, and social sciences, business and administration. However, the students' future educational or occupational intentions are defined in accordance with the international standard classification of fields of education and training, ISCED-F 2013 (UIS 2014), including the following fields: education, social sciences, journalism and information, business, administration and law, natural sciences, mathematics and statistics, information and communication technologies, engineering, manufacturing and construction, agriculture, forestry, fisheries and veterinary, health and welfare, and services. The international classification of education was used instead of the international standard classification of occupations (ISCO-08) (see ILO 2012) as it was expected to be more familiar to the participants, although the examples of both further studies and occupations were attached to options.

Participants of the Tests

This study examines the digital skills and digital technology usage of altogether 11,820 Finnish lower and upper secondary school students. Figure 2 illustrates the division of participants into two separate samples in relation to the Finnish education system. In both samples, the sampling took place by geographical areas (by six Regional State Administrative Agencies) and municipalities. At the school-level, however, individual schools could choose not to participate in the study. Further, within the participating schools not all classes were enrolled in the study, but the entire participating class was tested at a time to prevent individual-level selection in the study. All in all, it is clear that neither sample in this study satisfies the requirements of randomness for a multistage sampling. Nevertheless, the relatively large sample size of this study reduces the likelihood of a sampling process error compared to similar case studies in the context of education, which are typically based on a much smaller sample size. This is due to the general fact that as the sample size increases, it approximates the size of the target population, and therefore, inevitably approaches its characteristics. For this reason, it can be assumed that, the samples of this work provide a valid starting point for the scientific analysis. Nevertheless, articles based on these samples are not intended to generalise any actual statistical models with effect sizes from sample parameters to the target population level, as there is no methodological basis for this. Instead, the samples in this study are intended to provide a window through which to study the phenomenon, the factors behind it, and the relationships between these factors on the basis of a relatively large sample.

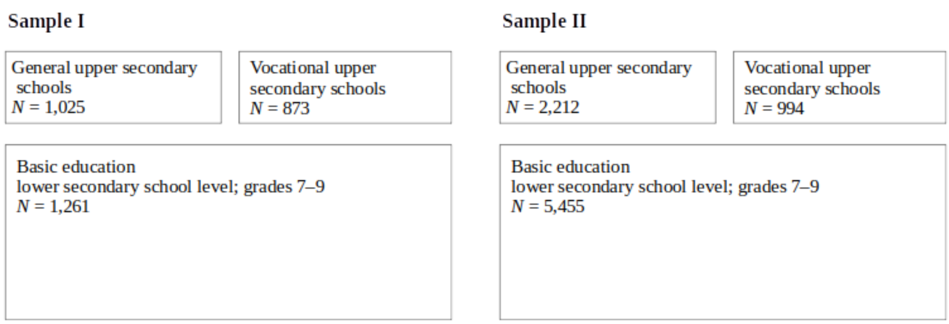

Figure 2. Participants in the Samples I and II in Relation to the Finnish Education System.

Sample I

The sample I data was collected during a pilot study in Finland during years 2014 and 2015 from 41 secondary (grades 7–9/9) and upper secondary level schools (study years 1–3/3). Altogether, 3,159 students were tested; 52% were male students, and 48% were female students. The age of the students ranged from 12 through 22 and their mean age was 15.9. Furthermore, 40% (*N* = 1,261) came from the basic education (lower secondary level), and 60% (N = 1,898) came from secondary education (upper secondary level). Of those upper secondary level students who participated in this study, 54% came from general upper secondary schools, while 46% came from vocational upper secondary schools. In the case of sample I the sampling procedure based on convenience sampling that is a type of non-probability sampling involving the sample being drawn from the population that is either close or otherwise easily available (Gorard 2013, 83–84). The problems and restrictions of this kind of potentially biased sampling are recognised, as noted above. However, this kind of sampling is said to be appropriate in the case of pilot testing (e.g., Gorard 2013, 84) which was the main purpose with the original ICT Skill Test. The sample covers the area of three Finnish Regional State Administrative Agencies: Southern Finland, South-western Finland and Western and Inland Finland.

Sample II

The sample II data was collected in Finland during the year 2017. Altogether, this sample consisted of 8,661 adolescents divided into two subsets – lower and upper secondary education students. The data from the lower secondary school students (grade 9/9) were collected as part of a project (Comprehensive school in the digital age) financed by the Finnish Prime Minister's Office (funding provided for Government analysis, assessment, and research activities). The participants came from 65 municipalities (149 schools) around the country, chosen by using a geographically representative sample of Finnish municipalities and their schools, as determined for the project by the Finnish Education Evaluation Centre. The sampling was based on stratified sampling strategy, which began at the regional-level, proceeding to the municipality-level within each regions, and resulted to a representative sample of Finnish municipalities. The sample covers the area of all Finnish Regional State Administrative Agencies: Southern Finland, Eastern Finland, South-western Finland, Western and Inland Finland, Northern Finland, and Lapland, proportional to the population of the regions. Altogether, this subset consists of 5,455 9th graders, aged 15 to 17.

The data set for the upper secondary school was collected as part of a project (Occupational restructuring challenges competencies) financed by the Strategic Research Council (SRC) at the Academy of Finland. The participants for this subset came from 43 municipalities (88 educational institutions) around the country and consisted of 3,206 secondary level students ages 15 to 22. Of the participants, 69% come from general upper secondary schools, and 31% from vocational upper secondary schools. The sample was constructed on the basis of the previous sample so that same size municipalities were selected from the area of same six Regional State Administrative Agencies for this new sample. Since many small municipalities in Finland provide upper secondary level education together with their neighbours, the number of municipalities and participating schools in this sample was lower than in the sample of the lower secondary education subset. The sampling still retains the same proportion in relation to the population of the regions as in the basic education subset.

Analysis

Data preparation

In the case of both test versions, the research variables had to be created using a structural query language (SQL) from the raw data which was stored in the test applications' relational database. Through this process, the raw data including transactions, choices and responses from database was converted to a two-dimensional research data matrix with variables and values that enabled the processing with statistical programming language (Python) and software (SPSS). The preparation phase included also the analysis of missing data. The examination of missing values is important for several reasons (Kwak & Kim 2017, 407), namely to avoid reducing the available data, compromising the statistical power of the study, and disputing the reliability of its results by causing a significant bias and degrading the efficiency of the data. Emphasis was put on preventing the problem of missing data in advance and the missing values which still passed this sieve were carefully examined.

Missing data causes two types of problems; bias and error. While bias causes an external validity problems, error causes defects in the hypothesis testing. (Newman 2014, 377–378.) According to Roderick Little and Donald Rubin (1990, 294), it is common in social sciences to use imputation, weighting and direct analysis of the incomplete data. Imputation could sound attractive, but it has serious pitfalls and should only be used with caution. Weighting, instead, is applicable only with monotone patterns of missing values as it ignores the missing cases and gives each of the involved cases a new weight to compensate for the missing cases. (Little & Rubin 1990, 294–296.) Newman (2014, 387) recommends that in the case of construct-level missingness, missing values are imputed applying a maximum likelihood or multiple imputation if 10% or more of the sample is made up of construct-level partial respondents.

The test application was designed to prevent the missing values. Therefore, the test phases and items and sub-tasks were mandatory (an empty value prevented proceeding). In those cases where participants dropped out before the test ended, their data was not saved to the research database. This automatically blocked the collections of incomplete response sets to the database. In some schools old and outdated web browser which did not support input validation functionality were still in use. This led to missing values in survey answers being included in the data despite the efforts made to prevent them. In this case the missingness refers to the construct-level issue as the missingness of the values is not associated with observed values. However, it does depend on other missing values and the missingness is not random as the missing values concentrate on certain respondents (see e.g., Newman 2014, 375). Missingness did not impact specific schools, as the old browser versions were still in use in a large number of Finnish schools during data collection. Nonetheless, in the end, only less than 1% of the participants had missing values. Thus, in this study, due to the large sample size and only a small proportion of missing data, the missing values in usage habit survey responses were left untreated. Instead, if there occurred missingness in the background information (such as gender, age or education) this led to the exclusion of a particular participant out of the data.

Another preparatory analysis concerned outliers. Outliers are extreme or incorrect values, which lie outside the overall distribution or pattern of variables (Gordon 2015, 422). Outliers can significantly influence the statistical evaluation (like distorting the mean and standard deviation of a sample), resulting either in overestimation or underestimation of the values. (Kwak & Kim 2017, 407.) Traditional regression models, in particular, have been said to be sensitive to outliers (e.g., Huang & Tzeng 2008, 14). Outliers may originate in data errors caused by faults in data entry or management or be correct values suggesting the need of subgroup analysis or demonstrate the inapplicability of the applied methods. (Gordon 2015, 422–424.) According to Kwak and Kim (2017, 410), there are three methods for treating outliers: trimming (i.e., excluding), winsorisation (i.e., modifying) and robust estimation.

Before the actual analyses, the outlier values in the respondents' background information were examined and the respondents who did not belong to the target group or had deliberately misused the test application were removed from the data. There were two causes that led to the removal of the respondents from the data. Firstly, if time used in the original test was less than 6 minutes and in the renewed test less than 9 minutes (as the short execution time indicated giving up or messing with the test system), the person was excluded from the data. Secondly, if the respondent’s age was under 12 or higher than 22 (the lower values were interpreted as mistakes or misleading actions and the higher values were removed due to their rareness), the person was not included in the data. Since the intention was to apply regression analysis to analyse the data, before analysis all the variables included in the regression analyses were standardised with min-max normalisation (e.g., Suarez-Alvarez, Pham, Prostov & Prostov 2012) to range between 0 and 1 and the influence of outlying values was examined during the analysis, for example, by examining regression residuals and possible influence of rare observations on the particular results.

Description of Multivariate Analysis

Except for the analysis in the first and third articles, which focus exclusively on the existence and magnitude of gender and educational differences exploiting bivariate analysis and thus serve as preliminary studies to confirm the need for further examination, analysis in the original articles utilises mainly multivariate statistical analysis. Multivariate models suit for social sciences, since the social life consists of multiple intertwined factors (e.g., Baur & Lamnek 2007, 3120). Lee Cronbach and Richard Snow (1977, 116) have reminded that learning and skills are to the greatest extent multivariate as every performance of an individual can be represented by a set of values describing the aspects of the performance. They have addressed that performance is measurable through multiple indices like errors, latencies and resistance which are often just moderately correlated and may not necessarily evolve simultaneously.

As in social sciences in general, issues related to education are typically characterised by the relationship between individuals and society, as individuals interact with the social conditions to which they belong. The individuals and the social conditions are understood as a hierarchical system of individuals nested within social groups, which allows this system to be observed at different levels and to define variables at each level. Therefore, research into the relationships between individuals’ descriptors and social contextual variables, i.e. the impact of group-level characteristics on individual-level outcomes, is called a multilevel research. (See e.g., Hox 2010, 1; Asparouhov & Muthen 2006, 2718.) Although such design is nowadays a popular approach in education-related social science research, this study is not particularly interested in describing the differences within and between schools, as digital engagement is expected to be more closely related to young people's extracurricular activities than to characteristics of schools. In contrast, digital engagement of young people is presumably related to regional factors linked to school neighborhood, but the available data did not allow an analysis of such characteristics. For this reason, the analyses of the articles in this study are limited to multivariate methods.

The multivariate analysis involves, as the term suggests, more than two variables. In fact, according to a strict definition, the multivariate analysis involves at least two dependent and at least two independent variables. Most multivariate methods, like the regression analysis and the analysis of variance which were mainly conducted in articles of this dissertation, are special cases of general linear methods (GLM), used to generate numerical solutions to differential equation. (e.g., Baur & Lamnek 2007, 3120–3121.) The multiple regression analysis, which was applied in the second and fourth articles of this dissertation, is an extension of simple linear regression and produces an equation that predicts the dependent variable from independent variables. The model for the multiple linear regression is formulated as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_p x_p + \varepsilon$$

where y is the dependent variable, x is the independent variable, β_0 is the constant or the intercept, $\beta_1$represent the slope (beta coefficient) for x_1 etc., and ε is an error term meaning an unexplained variation, treated as a random variable, in the dependent variable. The model parameters β_0, β_1, β_2, … β_p and ε needs to be estimated from the data. The multiple regression analysis allows an analysis of the relationships between one continuous dependent variable and two or more independent variables, but the association within variables does not necessarily imply causation. (Nathans, Oswald & Nimon 2012, 1–2; Yan & Su 2009, 1–3). Because this study does not seek causal explanations, but is rather concerned with the degree and the nature of the association between the analysed variables, multiple regression analysis is applicable for the purposes of this study.

According to Amanda Fairchild and David MacKinnon (2009), the relations between variables are often more complex than simple bivariate relations between a dependent and an independent variable and the relationships can be modified by a third variable acting as suppressor, confounder, covariate, mediator or moderator. Moderation refers to a situation, where the prediction of a dependent variable from an independent variable(s) differs across the levels of a moderator variable. A moderator can influence on the strength and/or the direction of the relationship by increasing, decreasing, or changing the impact of the predictor variable. (Fairchild & MacKinnon 2009, 87 & 91). In the second article, the moderator nature of gender is analysed running the multiple regression analysis separately for both genders. The basis for separate tests arise from the difference of the equations. According to Gordon (2015), the Chow test measures whether two linear regressions are equal, i.e. whether an entire regression model differs within subgroups. The Chow test statistic is described as:

$$\frac{\left(S_c-\left(S_1+S_2\right)\right)/k}{\left(S_1+\mathrm{S}_2\right)/\left(N_1+N_2-2k\right)}$$

where S_c is the sum of squared residuals from the combined data, S_1 and S_2 are the sum of squared residuals from the first and second separately run group, N_1 and N_2 are the number of observations in these groups and *k* is the total number of parameters. The Chow test statistic follows the *F* distribution with k and degrees of freedom being N_1+N_2-2k. (Gordon 2015, 315–320 and 348.) The Chow test is applicable to determine whether the independent variable has different impact on different subgroups of the sample. In the case of gender in the second article, the Chow test statistics indicates that gender acts as a moderator variable for both dependent variable (skill) and independent variables (usage).

In the case of regression analysis, it is important to evaluate the statistical significance of the estimated parameters in regression models along with the goodness-of-fit of the model and the measures of the model's predictive power. The *F*-test (analysis of variance) of the overall significance of the regression model is a specific form of the *F*-test measuring a model with no predictors to the specified model; the rejection of the null hypothesis means that the fit of the intercept-only model is significantly reduced compared to specified model. The *F*-test also enables to compare different models and to decide which model best fits to the sample. The *t*-test, instead, measures the significance of individual coefficients within each model. (e.g., Gordon 2015, 184–185; Montgomery, Peck & Vining 2015, 25–29.) The predictive power refers to the *R*-squared (R^2) value, i.e. the basic measure of the proportion of the variance in the dependent variable that is explained by the predictors. The value of R^2 range between 0 and 1; values closer to 0 represent a poor fit and value 1, a perfect fit. It should be noted that the value of R^2 increases as additional predictors are added into the model. An adjusted *R*-squared is thus more suited as it deals with this issue by reducing the degrees of freedom concurrently with added variables. (e.g., Gordon 2015, 199–200; Montgomery et al. 2015, 48; Yan & Su 2009, 166.) The Durbin-Watson test is the test for confirming the critical assumption of independence, i.e. detecting the presence of autocorrelation in linear regression (Montgomery et al. 2015, 475–477;

Yan & Su 2009, 235). In addition, the normality of the residuals and their distribution, as well as the potential impact of the outlying observations and their influence on the results, should be evaluated in the case of all types of regression models (Gordon 2015, 425–426; Mood 2010, 80–81). The model fit estimates described above are reported in original articles.

In the fifth article the dependent variable (students' intention to study or work in the ICT field in the future) is dichotomous (intended or not) and therefore it requires the utilisation of logistic regression. According to Chao-Ying Peng and Tak-Shing So (2002, 35) logistic regression is suited for examining the relationships between a dichotomous, for example qualitative, dependent variable and one or more independent predictors. In its basic form, logistic regression applies a logistic function to model a binary dependent variable. Possible values of the dependent variable are either 0 (i.e., indicating non existence) or 1 (i.e., indicating existence). The difference between the linear and the logistic regression is that the logistic regression transforms the mean of the dependent variable by applying a logit link function, whereas in the linear regression dependent variable is left untransformed. The reason for the logit transformation is that the categorical outcome variables are meant to approximate the probability of observations falling into these possible categories causing the relationship between the covariates and the dependent variable to be *s*-shaped, not linear. In the logistic model, the logarithm of the odds (the log-odds) for the existence (value 1) is a linear combination of one or more independent variables. The independent variables can be either categorical or continuous variables. (Mood 2010, 68; Peng & So 2002, 35; Pampel 2000, 10–18.) Having multiple independent variables construct a complex logistic regression described as (Mood 2010, 68):

$$\ln\left(\frac{\pi}{1-\pi}\right)=\beta_0+\beta_1 x_1+\beta_2 x_2+\ldots+\beta_k x_k+\varepsilon$$

where π is the probability that the dependent variable $y = 1$. For interpretation purposes the logit is usually transformed to odds; the odds that $y_i = 1$ is obtained by exp(logit), and the probability by:

$$\frac{\exp(\text{logit})}{(1+\exp(\text{logit}))}$$

Therefore, the logit varies between -∞ and ∞, but translates to probability which ranges from 0 to 1. (Sperandei 2014, 15; Mood 2010, 68.) Usually the results of logistic regression are presented either in terms of odds ratios (OR) or log-odds ratios (LnOR) (Mood 2010, 68).

The evaluation of the goodness-of-fit of the logistic regression differs from the evaluation of ordinary linear regression. Instead of *F*-test, the overall model significance for the logistic regression is examined using the Chi-square test. Unlike in the case of the traditional *R*-squared, the value of the Nagelkerke *R*-squared is commonly used to examine the proportion of variance explained by the independent variables. In addition, the Hosmer-Lemeshow test is used for evaluating the goodness-of-fit for logistic regression models measuring, whether the observed values match the expected values in the subgroups of the model population. (Hosmer & Lemeshow 2000, 143–166; Nagelkerke 1991.) As with other types of regression analysis used in the original articles, the above measures are reported in more detail in the fifth article which applies logistic regression. Carina Mood (2010, 79) has raised an important point regarding the logistical regression: because the coefficients of logistic regression are dependent on both the effect size and the magnitude of undetected heterogeneity, coefficients between models or samples cannot be straightforwardly interpreted or compared which is a usual practise with linear regression models. Although these issues should be known by sociologists applying quantitative methodology, they are typically ignored. In the fifth article, this is taken into account and such comparisons are deliberately avoided.

Long-term Preservation of the Data and the Instruments

The FAIR Principles seek to foster findability, accessibility and reusability of research data and to further scientific data management and stewardship (Wilkinson et al. 2016). However, these principles do not obscure the principles of research ethics or other regulations, such as the national guidelines for investigating minors. According to the Finnish National Advisory Board on Research Ethics (TENK 2009, 6), scientific research taking place in educational institutions can be conducted as part of the normal school day, and the guardian's permission is not required if the head of the school has assessed the study to provide useful information for the school. Research licenses have therefore been requested from school leaders or from other authorities depending on the regulations of each participating municipality. Due to the terms of these research licenses concerning under-aged participants and the consents requested from the participating students, the utilised data cannot be opened and shared openly. However, in accordance with the principles of proper data management, the data is stored in digital long-term storage at Zenodo. Zenodo is a general-purpose open-access repository under the European OpenAIRE program, operated by the European Organization for Nuclear Research (CERN), allowing the deposit of data sets, software and any other research related digital artefacts. The stored research data consists of the following data sets:

1. Kaarakainen, M.-T. (2019). The original ICT skill test data [Data set]. Zenodo. DOI: 10.5281/zenodo.2605006

2. Kaarakainen, M.-T. (2019). The renewed ICT skill test data; basic education level subset [Data set]. Zenodo. DOI: 10.5281/zenodo.2605515

3. Kaarakainen, M.-T. (2019). The renewed ICT skill test data; secondary education level subset [Data set]. Zenodo. DOI: 10.5281/zenodo.2605513

The source code of the applications used for the research are also stored in Zenodo for long-term preservation. Unlike datasets, source codes have been opened under restricted access. On request and for a valid reason, these research applications can also be used in other studies, although they need to be upgraded to better match the current digital environment and visual look of applications. The test applications should also be upgraded to run with the currently supported PHP and database versions. The language of the research applications is Finnish and in the renewed test also Swedish, limiting their re-usability. However, the renewed test application supports multilingualism, so other language files can be added to the application, although this necessitates some further development. The stored source codes consist of the following repositories:

1. Kaarakainen, M.-T. (2019). The source code of the original ICT Skill Test application [Software]. Zenodo. DOI: 10.5281/zenodo.2621283

2. Kaarakainen, M.-T. (2019). The source code of the renewed ICT Skill Test application; Finnish version [Software]. Zenodo. DOI: 10.5281/zenodo.2621306

3. Kaarakainen, M.-T. (2019). The source code of the renewed ICT Skill Test application; Swedish version [Software]. Zenodo. DOI: 10.5281/zenodo.2621321

6 Results

This dissertation thesis provides answers to four research question. The first question, *To what extent the gender makes a difference in digital engagement of students in Finnish lower and upper secondary schools?*, is discussed in detail in the article *Differences between the genders in ICT skills for Finnish upper comprehensive school students: Does gender matter?* (Article III). This article examines the differences between genders in digital skills among lower secondary education students. The gender-related topic is also addressed in other articles even though they focus on other topics. The theme of the next question, *How does the age of Finnish upper secondary school students affects their digital engagement?*, is central to the original article: *Seeking adequate competencies for the Future: Digital skills of Finnish upper secondary school students* (Article IV). This article concentrates on examining the digital skills of Finnish upper secondary school students and how these skills are associated with students' educational choices, future educational and occupational intentions and the age of the participants during the secondary education studies. Similarly to how gender is featured in the other articles, age is also an important variable when examining digital skills and usage in the other articles, although they are more focused on other factors.

The third question, *How are gender-segregated fields of education and future intentions associated with digital engagement of 12–22 -year-old Finns?*, is discussed in three of the original articles. The issues related to education level are central in the first article (*Performance-based testing for ICT skills assessing: a case study of students and teachers' ICT skills in Finnish schools*) and the second article (*Information skills of Finnish basic and secondary education students: The role of age, gender, education level, self-efficacy and technology usage*). The first article focuses on the measurement of digital skills and the classification of such skills, but also on the differences in digital skills between lower and upper secondary school students, as well as between general and vocational secondary education students. The second article analyses especially one of the areas of digital skills, information skills that refers to the ability to use digital technologies for searching, selecting, processing, and evaluating information. In addition, the second article analyses the usage habits of digital technologies and the relationship of usage habits and information skills among students. In the fourth article the role of gender-segregated fields of education and the future intentions of young people are the main focus of interest. The last question, *To what extent and in what ways does digital engagement accumulate, as exhibited by certain individuals more than others among Finnish lower and upper secondary school students?,* is particularly relevant to the second and fifth articles. The fifth article, *Digital abilities and ICT intentions of future labor market entrants in Finland,* examines the digital abilities of Finnish upper secondary education students concentrating especially on students' intentions to study or work in the ICT field in future. Although the accumulation of skills and usage and their interrelationships are central to these two articles, as a theme it is relevant to all of the original articles included in this dissertation thesis.

Digital Engagement by Gender

The role of gender in relation to digital skills is a central theme particularly in the third article (*Differences between the genders in ICT skills for Finnish upper comprehensive school students: Does gender matter?)*. The article analyses the data concerning only the lower secondary education students in the sample II, applying the renewed ICT Skill Test. The results of this article shows that there is only a small, but statistically significant difference between the genders, in favour of female students, when analysing students' performance in the ICT Skill Test at the total score level. A more detailed item-level analysis, however, reveals significant differences between the genders in digital skills according to the subject matter of the test item (see table 1 of article III) as male students tend to get higher scores from more technical-oriented items than females, and female students score higher in school work -oriented and social interaction -related items than male students. Therefore, the differences in digital skills between genders tend to relate to the subject matter of the test, implying that these differences are rooted in more profound gendered preferences and attitudes toward technology.

The first article (*Performance-based testing for ICT skills assessing: a case study of students and teachers' ICT skills in Finnish schools),* based on sample I (both lower and upper secondary school students), where gender differences are just one of the topics to be considered, confirms the above-mentioned results. The results of this article, based on the version of the ICT skill test emphasising computer literacy at the expense of wider digital skills, show that the overall performance of male students is slightly better than that of female students (table 3 of article I). However, the more substantial gender divide appears in the advanced and professional technical skills, in which male students clearly outperform the female students. These results are consistent with the results of the third article, as presented in the previous paragraph, and with the traditional understanding of males being more technically-oriented than females. However, along with this, the results of the first article emphasises that the more technical the tasks, the smaller the number of students who master them and the greater the differences between the genders became. Thus, male students clearly dominate technical skills, but this dominance in the most technical tasks is in fact caused by a relatively small group of technically competent males.

The fifth article (*Digital abilities and ICT intentions of future labor market entrants in Finland*) focusing on the upper secondary school students in sample II and applying the renewed ICT Skill Test, confirms (table 2 of article V) that the medium-related digital skills, necessitating abilities to use the functionalities of the devices, software and the Internet, and especially programming skills, consisting of logical reasoning, web programming and knowledge of databases, tend to be especially male-dominated areas of expertise. In the fifth article, gender also stands out as an influential factor for students' intentions to apply to study or work in the ICT field in the future (table 4 of article V), leading to the assumption that the majority of the possible future ICT applicants will continue to be consist of mainly male students in the future.

The second article*, Information skills of Finnish basic and secondary education students: The role of age, gender, education level, self-efficacy and technology usage,* applies the original ICT Skill Test examining information skills and the digital technology usage habits of participants from both lower and upper secondary schools. Based on the results of this article, gender serves as moderator variable, as both the skills and the usage of digital technology between males and females are different in terms of the areas of expertise and the types of usage. The results (see table 4 of article II) shows that social use is the most frequent type of digital usage among both genders, followed by personal use. Social use includes the usage related to communication, maintaining social relationships, networking, sharing one's own digital content in networking sites and playing multiplayer games. Personal use, instead, includes individual game playing and the usage of different kind of digital entertainment services. The results highlight the importance of social relations and recreational leisure in the daily, digitalised life of young people in Finland. Economic use, including public and commercial services and learning- and information-oriented usage, is far less frequent among young Finns than social use and personal use. Cultural use, such as creating one's own digital content and sharing digital contents on different kinds of online services, is the least frequently cultivated type of usage. The results show that male students are more active in economic use and personal use than female students, whereas female students are more active in cultural use compared to males. Moreover, the results of the second article show that male students are more versatile users of digital technology than female students. However, the distribution among male students is wider than among female students as both the most restricted and the most diverse users of digital technology are male students.

In summary, gender appears as a social category that produces differences in young people's digital engagement. Both the digital skills of the students and their digital usage differ between male and female students especially with regard to their type and domain, rather than in terms of quantity of usage or level of skills. This fact indicates that gender differences in digital engagement are largely domain-specific and related to gendered preferences and interests, in other words tendencies towards the ways of experiencing digital technology and available digital afforcances. Because the patterns of these preferences appear clearly in the data concerning lower and upper secondary school students, they are most likely to develop during the early years of childhood and youth.

Digital Engagement by Age

The fourth article, *Seeking adequate competencies for the Future: Digital skills of Finnish upper secondary school students*, examines students of upper secondary schools (sample II) and applies the renewed ICT Skill Test. The results (see table 2 of article IV) indicate that age as an explanatory variable has a significant impact on students' digital skills among 15–19 year-old upper secondary school students in Finland. The skill-increasing effect of age is stronger among those Finnish students who study in vocational upper secondary schools than among those who study in general upper secondary schools. Based on cross-sectional data, vocational school students seem to improve their skills during the upper secondary education studies to the extent that they manage to close the skills gap that is clearly visible between general and vocational upper secondary school students at the beginning of upper secondary level studies. As commented on the article, this is an interesting and contradictory observation, as vocational training has not been considered as effective as academic education in the development of such digital problem-solving capabilities. It is evident that the curricula and the learning objectives in vocational education seem to be more oriented towards occupational skills' requirements and students adult life as a citizens of the information society, when compared to the curricula in general education which, in turn, focuses more on the use of digital technology in learning-related contexts. This is assumed to be the cause of the positive impact on the digital skills of vocational upper secondary school students.

The fifth article, *Digital abilities and ICT intentions of future labor market entrants in Finland*, examining the upper secondary education students from the sample II and applying the renewed ICT Skill Test, brings out the importance of age for young people's digital usage. With regard to the students' digital usage (see table 2 of article V), with increasing age of the students, economic use of technology turns out to be more frequent and in fact the most popular usage domain among the oldest participating students. This is most likely explained by the economic independence of older young Finns in the sample and the curricula requirements in upper secondary education as these two together increase usage related to public and commercial services, as well as learning- and information-related usage. Unlike economic use, age as an independent variable is not seen affecting on the frequency of social, personal or cultural use of digital technology of 15 to 22 year-olds.

Overall, the original articles show that age, even among young people, has an impact on both digital skills and digital usage habits of digital technology. The importance of age as an independent variable among young people is explained, in particular, by the increasing versatility of technology use with age. On the contrary, based on the results of the fifth article, age is not considered to be a relevant factor for the likelihood of students expressing their desire to study or work in the ICT field in future. Thus, age is unrelated to the emergence of gendered educational preferences or at least these preferences evolve at an earlier stage of childhood and therefore are not scrutinisable with the available data.

Educational Choices and Digital Engagement

The age-related results suggest that education could have a central role in digital skills as the digital engagement increased with the age of the students. Next, this aspect will be discussed in more detail from the point of view of the level and the field of education. The first article shows (table 5 of article I) that there are considerable differences in skills between lower and upper secondary school students. In particular, there are large differences in tasks that require basic technical know-how. When examining the tasks belonging to the advanced or professional levels, the difference between students from different education levels remains more minor even though upper secondary school students are still performing significantly better than lower secondary school students. The second article gives evidence that education level is, in fact, the most influential factor in digital skills among the examined factor variables (gender, age and education). The results (see table 6 of article II) also suggest that the effect of education is even more significant among male students than female students as the difference between lower and upper secondary school students' skills is more wider in scale among male than female students.

In the second article, the level of education is also linked with the usage of digital technology among students. In fact, the relationship between the education level and usage is more evident than the similar relation of usage and age (see table 5 of article II). Education level increases the students' overall use of devices and their digital engagement in domains of economic, social, personal and cultural use and the versatility of their digital usage. Particularly, on the upper secondary education level, students' digital usage related to economic purposes increases. Together with economic use, social use and the versatility of students' overall usage of digital technology are notably higher among upper secondary school students than among lower secondary school students. On the contrary, the increasing effect of education level on personal use and cultural use domains is only minor. Furthermore, students' overall digital engagement and versatility of usage increase together with the increase in the education level. The increase in versatility is most likely due to the fact that the information- and learning-oriented use becomes more abundant with the upper secondary level studies as nowadays in Finland the studies in upper secondary schools require the regular use of digital devices for learning. As has already indicated in relation to age, economic use also increases as the result of abundant use of different public and commercial online services among older youth. Both of these have a diversifying effect, maturing students' daily use of digital technology.

In addition to the level of education, it is important to examine the other aspects of education as well in order to achieve a comprehensive picture of the importance of education in digital engagement. The first article indicates that besides the differences between the education levels, there are also differences within levels of education as general and vocational upper secondary school students differ from each other in terms of their digital skills (see table 5 of article I). Here it should be remembered that in Finland the vocational education covers altogether eight fields of education and includes more than 50 vocational qualifications. Therefore, the differences within upper secondary education level, constituting from a diverse set of educational choices instead of a simply general/vocational division, needs to be taken into account. This is especially the purpose of the fourth article as it aims to take into account the multidisciplinary nature of Finnish secondary education.

The fourth article shows (figure 3 of article IV) that educational choices in general upper secondary education (i.e., did the student take part in the advanced or basic syllabus in mathematics) and especially in vocational upper secondary education (i.e., the field of study the student participated) are of considerable importance. In fact, the difference in the digital skills between the worst and the best performing group (i.e., educational choice) is more than double. The best performing students are students from vocational upper secondary schools studying either in a field of natural sciences (qualification in ICT, specialisation in software development) and in a field of culture (qualification in audio-visual communication), and students from the general upper secondary schools studying advanced syllabus in mathematics. In contrast, the weakest performing students are those vocational upper secondary school students studying in a fields of natural resources and environment; tourism, catering and domestic services; and social services, health and sports.

The importance of the different fields of education in digital competence are not only related to the current educational choices but also to the students' future educational and occupational intentions. In this dissertation thesis, the future intention is based on the students' own announcement of the field in which they are planning to apply for further studies or to work at the end of their current education, as operationalised on the basis of the international standard classification of the fields of education and training (ISCED-F). As indicated in the fourth article (see table 5 of article IV), digital skills vary greatly among students depending on in which fields students intend to apply for further study or work in the future. The students with the best digital skills report their future intention to be information and communication technology (ICT) or natural sciences, mathematics and statistics. In contrast, students with the least digital skills report favouring the fields of agriculture, forestry, fisheries and veterinary, services and education (vocational upper secondary school students) or basic syllabus in mathematics (general upper secondary school students). It can be seen that the most skilled students announce preferring the traditionally more male-dominated fields of education, whereas the students with weaker digital skills tent to favour more female-dominated fields of education and occupations. In terms of digital engagement, the skills gap is therefore clearly associated with the gender-segregated fields of education indicating that the horizontal segregation in the digital engagement of Finnish young people is an evident fact.

All in all, based on the results of the original articles, education is identified as the most significant single structural factor that produces differences in digital engagement among youth. Education manifests itself as a categorical social hierarchy, as the level of education increases young people's digital engagement. At the same time, the observed differences in digital engagement within the same level of education are connected to the gendered preferences and interests. Because digital engagement is most likely exhibited by students in the male-dominated fields of education, it is related to factors' that lead young people to drift into gender-segregated fields of education. As both educational choices and technology orientation are heavily gendered, they tend to reinforce each other and thus exacerbate gender differences in relation to digital engagement and the ability to take advantage of the potential digital affordances among the future citizens of the information society.

Accumulation of Digital Engagement

The last research question, *To what extent and in what ways does digital engagement accumulate, as exhibited by certain individuals more than others among Finnish lower and upper secondary school students?*, aims to draw together the themes that pass through all the five original articles, in one way or another. These themes are examined by reviewing the results of the original articles relating to the relationships within and between the digital skills and usage, focusing on, in particular, compoundness and sequentiality of digital usage and skills. Particularly, the fifth article give evidence of the compoundness of digital skills. Based on its results (see table 2 of article V), having skills in one area also increase the likelihood of having other kind of digital skills as the correlation between medium- and content-related skills is notably strong (r = .72).

Figure 3 illustrates this phenomenon of the compoundness of digital skills. The figure is produced from sample II and includes both lower and upper secondary education students. As can be observed, the figure shows a clear pattern how medium-related and content-related skills correlate with each other; usually if the individual masters medium-related skills he/she also possesses content-related skills (point a). The figure also shows that the correlation between content- and medium-related skills is stronger among male students (Pearson’s r = .77) than among female students (Pearson’s r = .69) as the blue dots form a steeper curve relative to the green crosses, indicating that the compoundness of digital skills is stronger among male than female students. However, the figure also confirms that having one type of skills does not necessarily guarantee the mastery of other types of skills; as can be observed, the tested students could master, for example, medium-related skills quite well (point b) without having the same level of content-related skills, and the other way round (point c).

Figure 3. The Relationship Between Content- and Medium-Related Digital Skills (Pearson's r = .72) Based on Data from Sample II (N = 8,661).

The results of the fifth article provide evidence also for the compoundness of digital usage. When looking at the correlations (see table 2 of article V) between the versatility of use i.e., how many usage targets an individual has at least on occasionally basis, and activity in different usage domains, it is evident that activity in economic, cultural, social and personal usage domains correlates remarkably with the versatility of overall usage. In addition, the activity in a particular usage domain correlates with the activity in other domains. Social and economic uses, in particular, seem to increase the likelihood of being an active user in all other domains of usage as well. The least compounded features describe the personal use which correlates at moderate level only with social use while its correlations with other domains remains negligible.

In contrast to compoundness, sequentiality of digital engagement relates to the relationship between digital skills and usage describing how digital engagement accumulates. This question is a central theme in the second and fifth article as they examine the relationship between usage and skills. Based on the results of the second article (see table 6 of article II), the versatility of use is, in particular, associated with favourable digital skills. Results also indicate that certain kinds of usage increase skills more than other usage purposes, as economic use correlates with skills more than other usage domains. Furthermore, the skill-increasing effect of usage is not the same for both genders. The clearest example is social usage which increases male students' skills, but not the skills of female students. The more detailed examination in the second article reveals significant gender differences within this usage domain between genders, and the main distinguishing activity between male and female students within the social use domain is whether or not the activity in this domain includes multiplayer gaming.

Based on the results in the second article, multiplayer video-games are a major usage purpose among social uses for males, but female students generally do not report gaming as their key usage activity. Instead, female students tend to emphasise social networking and digital communication within this usage domain. The results indicate that communication and networking activities among male students enable and support other, more exploratory and intrinsically meaningful online activities such as game playing. Instead, the importance of social interaction and companionship as such appears to be important reasons for social use among female students. For male students potential learning experiences seems to emerge as a part of their online activities within the social use domain precisely because social use among males contributes to wider exploratorial use of technology and the Internet. No similar positive effect exists among female students because maintaining social relationships and communication as usage purposes per se do not have the same skill-enhancing effect. The importance of this finding is that some usage habits, even within the same usage domain, are potentially more profitable than others. Consequently, the type of the digital usage is important for the accumulation of digital skills.

The fifth article provides additional understanding about sequentiality of digital engagement. Based on its results, especially economic use and versatility of digital usage are associated with digital skills (see table 2 of article V). However, these correlations in fifth article remain rather low, indicating that the association between usage and skills is not straightforward and a certain amount of digital usage does not automatically lead to the development of useful skills for each individual. Altogether, the findings of the second and fifth articles of this dissertation thesis admittedly show that digital engagement is sequential in nature. In addition, the results of these articles indicate that some usage habits are more profitable than others, and that there are noteworthy differences between genders in the patterns of the sequentiality.

In summary, digital competence and usage tends to come to mark certain individuals. More precisely, concepts of compoundness and sequentiality successfully describe the nature of digital engagement among Finnish adolescents. Skills and usage are intertwined and mutually reinforcing. Nonetheless, no amount of use or level of skills guarantees sufficient talent for success in the information society because the quality and type of digital usage is relevant to its power to produce relevant digital skills. Certain usage habits are more profitable than others and enhance such digital engagement that is more likely to be beneficial, providing the abilities to identify and exploit the action potentials of the available digital affordances.

7 Conclusion

The aim of this work is to contribute to the narrow scope discussions around digital technology in education. To be more specific, the purpose is to not only further the identification of the wide-ranging opportunities of digital technology, addressed as digital affordances, but also to raise awareness about the risks of digital exclusion because it severely reduces the opportunities for individuals in the information society in many areas of life. The results of this work confirm a number of previous research findings (e.g., Hatlevik et al. 2017; Hargittai & Shaw 2015; van Deursen & van Dijk 2014; van Deursen et al. 2011; Helsper & Eynon 2010) that have shown that gender, age and education are causing divergence in individuals' digital engagement leading to differences in individuals abilities to make use of digital affordances. This study also provides clear evidence that this kind of disparity, referred to as digital inequality, also exists in the Finnish society, as exemplified by the disparities among the lower and the upper secondary school students.

In addition to confirming previous research results, this study brings out fresh facts that will enhance and diversify the understanding of the issues of digital inequality and digital technology in education. To begin with, this work provides more accurate information on the gender differences in digital skills and usage, the results of which have been contradictory in previous studies (e.g., Correa 2016; Aesaert & van Braak 2015; van Deursen & van Dijk 2015; van Dijk 2013; Correa 2010; van Deursen & van Dijk 2010a; Fuchs 2009), when indicating that male students are consistently more competent than female students in tasks that require more technical knowledge or computer literacy, whereas female students possess higher skills in tasks related to school work and social interaction with digital technology. Thus, neither gender is better than the other, but the males and females tend to orientate to different domains of interest and expertise. Results of the articles included in this dissertation thesis therefore certify that there exist domain-specific gender gaps in digital skills and the issue is far more complex than the binary concept of being skilled or unskilled implies.

The more versatile digital usage of males, compared to females, seem to indicate that for many male students, technology, devices, and virtual environments are objects of exploration and experience offering thus more opportunities for learning than for the majority of female students whose technology use is more task-oriented and thus limited to the fulfillment of a present goal. This resonates with Robinson's (2009) findings about young people's digital usage. Males seem to be more likely engaging with Bourdieusian 'serious play' and 'studious leisure' during their technology use, while females' aspiration to reach a particular goal with technology prevents them from being exposed to such exploratorial usage habits. Under these circumstances, the interdependence of digital usage and digital skills increases the likelihood that beneficial experiences and digital action potentials will accumulate for males rather than for females.

Consequently, the results of this dissertation thesis emphasise the significance of gendered preferences toward technology. Disparities between genders in digital skills and usage suggest that gender differences are closely intertwined with preferences and attitudes, acquired via socialisation, causing gender-oriented interest toward technology and digital engagement. This observation provides support for van Dijk's (2013; 2005) assumptions that the unequal distribution of resources, especially the more personal ones, has a significant impact on digital inequality. The time spent by youth on digital technologies and the importance they give themselves to being online seem to be the most prominent resources that determine young peoples' attitudes towards digital technology. In the social relations of males technical aspects are presumably more valued and thereby they tend to produce more positive stance towards technology than females.

Of the factors studied in the original articles, education proves to be the most important factor that affects digital engagement. However, the link between education and digital engagement is multifaceted and does not just refer to the level of education. Specifically, the level of education has a particular impact on mastering the skills needed to use digital devices, applications or the Internet, and the skills enhancing effect of the education level is stronger among male students than among female students. Despite this, the level of education does not increase the digital skills of young people as such, but indirectly by diversifying digital usage and as a result of the requirements of upper secondary education studies. Similarly, the skill-increasing effect of age, shown in the results, is mediated through diversifying usage. In contrast, the educational choices such as the fields of study or curriculum within the same level of education emerge as factors by which digital skill differences are most clearly manifested. In general, better digital skills are noted by students studying in the male-dominated fields of education, whereas the skills of students in the female-dominated fields remain significantly lower. This kind of difference in digital skills is evident in terms of current education and future educational or occupational intentions, both of which are remarkably gendered among young people in Finland according to the results of this study.

Overall, the results of this study confirm the existence of clear horizontal segregation in Finnish education. Because gender-specific preferences affect the students further educational and occupational intentions, students' gendered orientations towards technology and their educational choices tend to reinforce each other and thus have a potentially far-reaching effects on individuals' life chances. The importance of the aforementioned is further strengthened by the fact that digital technology and related capabilities are central for the information society and thereby digital abilities are increasingly causing divisions between prosperous and excluded citizens by accumulating such capital for some individuals at the expense of others. The results of this work link superior digital abilities with the male-dominated fields of education, which are generally considered to be likely to lead to well-paid professions and whose demand in the labour market is expected to increase in the future (e.g., Falk & Biagi 2017b; Lindley 2016, 173), denoting the noteworthy risks of widening skill-based divide between the genders in the information society.

In the light of the results of this study, the horizontal segregation is particularly strong with regard to the attractiveness of the ICT field among Finnish upper secondary education students. The low share of females in digital education and workforce has long been not only typical for Finland but also a global problem (see e.g., Dass, Goodwin, Wood & Luanaigh 2015; Korte, Gareis & Hüsing 2014). The results of this study confirm the relevance of these concerns and stress the need to provide young people with intriguing information, role models and skill-related preconditions for digital education and labour market that not only increase the attractiveness of the field, but also challenge traditional gender roles and attitudes. This is important for equal opportunities so that both genders have equal opportunities in the future labor market shaped by digitalisation. However, it has proved to be problematic to find effective ways to influence to the gendered educational and occupational choices of young people (e.g, Cheryan et al. 2017). Here, alternative approaches based on a more sociological view of digital engagement can provide an untapped opportunities.

Referring to Tilly (1999), inequalities build on categorical differences emerging in the social contexts to which individuals are bound. These prevalent social conditions increase susceptibility of individuals to generate certain types of tendencies to perceive and experience digital technology and the Internet. The results of this study suggest that there is a special *digital habitus* through which individuals experience the world and their relationship with digital technology, constantly in relation to others. Habitus evolves over time as a combination of experiences and encountered circumstances. Through digital habitus, young people sense their own place with respect to others (see Bourdieu 1989) and it affects on, for example, the ways young people perceive different digital affordances meaningful for themselves. This underlines the importance of digital referents (see Helsper 2017a; 2017b) and social conditions for the evolution of young people's preferences and tendencies toward technology. For the young people, more important than the distribution of information, for example, as a part of student guidance, are the attitudes of the social reference groups to which they feel belonging to. Thus, the interventions for increasing digital capabilities or the popularity of the ICT field professions necessitate focusing on these social reference groups. Young people surrounded by other youth valuing digital engagement and technical capability are most likely to acquire the efficient skills to needed to actively participate in various online arenas and develop a positive attitude towards technology. The interventions should therefore be targeted at wider social units than just individuals.

The present social reference groups are typically not covered by formal education, but rather rooted in different online communities. These are, in fact, important and largely untapped properties that digital technology have to offer for education. This provides a perspective from which digital engagement appears to be an investment and commitment to learning of valuable skills for future citizens. Online communities combine globalisation, communication and collaboration, development of new artefacts and ideas and their further innovation creating interest-based learning environments. At best, these kind of interest-based learning environments provide young people a wealth of exploratory learning experiences leading to a positive stance towards technology and learning (e.g., Steinkuehler & Squire 2014). This kind of action exposes students to affordances and action potentials of digital artefacts through experimentation. Harnessing these fundamentally collaborative resources for learning purposes would provide genuinely authentic and motivating learning environments for students with different levels of skills and motivational interests avoiding the technocratic hyper-individualisation of learning and the instrumentalisation of digital technology in education.

However, the enthusiasm related to digital technology and the Internet in education includes the risk of using technology as a learning product in a way that does not promote the intended aspirations. Utilising overly ready-made and at the same time too limited environments in education do not leave room for students' exploratorial and experimental activities, and neither encourage self-production of digital content. Often such learning environments have been enriched with features familiar to users from social media connections aiming to create engaging learning experiences. However, the familiarity and ease of use of learning products is a two-sided issue from the point of view of competence development, because in order to develop, skills must be challenged. Despite this, most of these consumer products are definitely suitable for learning and teaching within their limitations. However, it must be remembered that they do not, in themselves, enhance students' digital skills or digital engagement. The driving force behind the educational objectives should not be technological advances, nor the mere use of new digital resources, but skills objectives and the relevant learning content and practices associated with them. Digital skills deserve their own learning objectives and pedagogical approaches aimed at achieving them.

As stated, many popular learning products promote independent learning instead of collaboration and dialogue. Such technology can have unpredictable and detrimental effects on students' learning and commitment to education. The risk of skill-based division in the information society, mentioned earlier in this chapter, is likely to be escalated by this kind of hyper-individualisation of learning. From the point of view of digital inequality, one of the central problems of this trend is that all too often in schools, students are expected to master the use of digital tools as a result of their digital leisure activities (e.g., van Dijk & van Deursen 2014, 156). Although admittedly young people have a lot of digital activities outside of school, there are limitations in self-learning of digital skills; do-it-yourself or trial-and-error learning is not enough to guarantee adequate digital skills to every individual (see Matzat & Sadowski 2011, 1). As the results of this study show, young people's digital skills are, above all, diverse. Therefore, there is a current and relevant concern relating to rapid digitalisation of education that the inadequate digital skills, at their worst, endanger the learning of some students. Formal education should be able to recognise students' shortcomings in digital capabilities and contribute to students' digital engagement so that learning these vital skills of the future does not remain the responsibility of the young people themselves. This presupposes that digital technology is not perceived as just a learning tool, but digital skills are seen as an important topic in itself, which is not abruptly internalised by all young people alongside other activities. Education should play a key role in moderating the disparities present among differently skilled young people in order to reduce inequalities in education and more widely in society (see also Pagani, Argentin, Gui & Stanca 2015, 157). Obviously, this requires preparedness and competency from the education system.

It should be remembered that both digital abilities and inequality are relational properties. As the requirements for digital engagement are constantly rising due to advancements in the surrounding technological milieu (e.g., van Dijk 2005; van Dijk & Hacker 2003) individuals are exposed to a constant risk of being left behind in various areas of the information society (see Facer & Furlong 2010). Understood as a relative matter, digital inequality is not a transient phenomenon and will not disappear as the younger generations of today grow older. Instead, the importance of digital inequality is expected to increase in future societies due to the increasing importance of digital capabilities in different areas of life. Therefore, the education system must not only offer adequate digital capabilities, but also to equip future citizens the abilities to maintain and further develop their own digital abilities in changing situations. However, it is equally important to realise that a society penetrated by digital technology is characterised by the diversification of opportunities that the digital engagement has to offer for citizens (see e.g., van Deursen & Helsper 2015, 47). The digital prospects enabled by digital technology for the individuals, such as future citizens or labour market entrants, are more versatile than ever before. Paradoxically, increasing digital prospects inevitably increase the threats to equal opportunities. Emerging digital affordances are therefore both a challenge and an opportunity for education system, when ensuring equal preconditions for children and adolescents to seize these opportunities.

Overall, the results of the articles included in this dissertation thesis emphasise that the compound and sequential dimensions exemplarily describe digital engagement among Finnish students. They are therefore apt concepts for describing accumulation of profitable digital engagement; skills of one kind and usage in some area are linked with increased engagement in other areas as well. The phenomenon also has a more negative side, as lack of capability or experience in some area increases the likelihood of falling behind in digital capability also more generally. Digital engagement also proves to be sequential in the sense that more versatile digital usage tends to be associated with advanced digital skills. In addition, some types of usages are more skill-enhancing than others, which makes the quality of usage more important than the quantity of usage as such. While compoundness cumulates digital engagement, as exhibited more by certain individuals than others, sequentiality of digital engagement increases the likelihood that those individuals also benefit the most from available digital affordances. Thus, in its extreme cases, the sequentiality of digital engagement describes the path either to the digital prosperity or exclusion, making it an important educational policy issue. The compound and sequential nature describing the digital engagement of Finnish students further implies that the existence of the third-level digital divide, referring to gaps in individuals’ capacity to translate their digital engagement into beneficial outcomes in their life (see van Deursen & Helsper 2015), is observable in present Finnish society. The negative effects of this development should be identified and prevented through education policy-setting.

It should be noted that active and versatile digital engagement increases the likelihood of encountering not only the benefits of digital technology, but also technology-related harms and negative or abusive Internet contents (see Blank & Lutz 2018). Various negative issues related to the Internet, such as spread of false information, sexual grooming of children, identity theft or other privacy issues, have recently received a lot of space in headlines in Finland and more widely around the world. Such concerns have sometimes encouraged opinions that the use of digital technology in education should be viewed critically and to consider restrictions on it. However, the negative aspects related to technology and the Internet rather require the fostering of digital well-being skills referring to individuals' abilities to cope with the negative aspects of the Internet and to control their activities and privacy while engaging in various beneficial activities through digital technologies (see Gui, Fasoli & Carradore 2017). Such skills are in fact emerging as a key component of digital skills and are not just about threat prevention but also about managing information or message overload and multi-tasking. The inability to cope with risks and harms associated with the use of digital technology and Internet threaten the most digitally inexperienced and unskilled individuals, and in particular, according to recent results (Scheerder, van Deursen & van Dijk 2019), less educated individuals and families. Therefore, education must recognise the importance of digital well-being and equip students with the ability to protect themselves from digital abuse and overuse. Promoting such abilities in education would also help to reduce concerns that children and young people today make considerable use of digital technology in their leisure and school activities. The digital activity of young people and digitality in general should not be seen as a passing craze, but a more permanent change that individuals have to learn to cope with.

This dissertation thesis also raises questions for future research. First of all, future research should scrutinise more closely the various manifestations of digital affordances and the factors that promote, or limit, individuals’ ability to exploit them successfully in their lives. This requires longitudinal, but also more qualitative approaches that delve into the experiences of individuals. The original articles of this dissertation study focus on the relationship between social structures and digital inequality. One of the topics for further research is to find out what kind of interaction processes between structural factors and individual experiences lead to digital inequalities and at what stage of life these could be effectively influenced by interventions. An interesting subject on its own for further research is also the gendered patterns of engagement, manifested in Bourdieusian notions of 'serious play' and 'studious leisure' in relation to digital gaming, as they appear to be characteristic of successful technology learning for certain young men, but only rarely for young women. Further, although previous studies (e.g., van Deursen & van Dijk 2014, 520) have found other structural factors, such as socio-economic background and residence, to be less relevant to digital inequality than the factors considered in this study, future research should investigate the role of socio-economic factors in the digital inequality of young Finns. In particular, the link between socio-economic background and residence, and the combined effect of these factors on the digital engagement of Finnish students needs to be the subject of future research as urban inequalities are considered a topical issue in Finland (e.g., Hyötyläinen 2016), referring to regional differentiation of welfare in urban areas. This is most likely to be related to the digital engagement of young people, differentiating their future exposure to digital affordances. Despite the importance of the factor, in this dissertation study this issue could not be analysed due to the deficiency of the data available. Therefore, in this dissertation thesis, the major flaws in the data, and thus in the study as a whole, are in fact related to the lack of available socio-economic background information. Addressing this shortcoming would also allow for multilevel modelling. For this reason, resolving this issue should be one of the key objectives of future research.

The more general limitations of this study are briefly outlined in this paragraph. As stated, research into digital skills, but also digital usage, has been plagued by conceptual ambiquity. This study does not make an exception here, as there is no commonly accepted definition of digital skills or digital usage. A viable practise for the researcher to remedy this issue is to formulate the research problem and describe the theoretical concepts used to achieve it in exemplary terms, so that the reader can reach the same comprehension of the use of these linguistic tools (see also Kivinen & Piiroinen 2006). The lack of a common conceptual language has a significant differentiating effect on research practices in the area of digital skills and usage. Conceptual ambiquity makes it also difficult to assess the soundness of evaluation methods as a whole, but also for a single instrument. This is the noteworthy limitation of the both ICT Skill Test versions used in this study. In addition, although performance-based evaluation eliminates the problems associated with self-evaluation, it also has certain inherent effects. The ability to solve practical tasks is a measure of the individual's skills, but for some participants, the limited area of expertise covered by the tasks may result the performance-based testing failing to tell the truth about a person's level of expertise. As a result, even this type of assessment method is not valid at the individual level for all participants. However, in quantitative research, which is not intended to provide explanations of the individuals' as such, this deficiency is remedied by the fact that individual-level measurement errors are ultimately mutually exclusive, providing thus a fairly reliable picture of group-level digital capability in large samples.

At this point, it is appropriate to return to the premise of this dissertation thesis, the need for sociological research in the context of increasing digitalisation of education. This study accentuates that the issues of digital technology in education deserve to be the subject of careful sociological research in order to improve the understanding of the role of digital technology and related social actions in education and more widely in the information society. When expanding the limited views of digital technology in education, wide ranging digital affordances are opening for education, but above all for individual students. These are resources that should be of interest to educators, as they form the milieu where learning and social action take place. A comprehensive picture of digital technology in education and more wider on society allows natural pathways to integrate education into students' overall lives and provide opportunities to build personally meaningful paths towards the future of individual students, while also ensuring adequate digital capabilities for citizens of the information society. Sociological approach also reveals the existence of digital inequality in Finnish education and pressures the education system to focus on preventing its negative effects. The presence of digital affordances and inequality, and in particular their interconnectedness, requires a fundamental change in the way of thinking and in the objectives of digital technology in education, as well as in educational policies that guide school practices. To begin with, this calls for replacing the simplifying technocratic objectives such as increasing the amount of devices and the use of digital learning materials or the measurability of the learning processes in schools with more ambitious educational objectives based on future skills requirements and promotion of equal opportunities for future citizens of the information society. Achieving such goals requires the identification of current digital inequalities and focusing, at all levels of education, on preventing the detrimental effects of such distributions on students' later life chances.

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Appendices

Appendix 1. The original ICT Skill Test test items and their categorisation, description and the results of item analysis.

Item	**Description**	***P***	***D***	***r***
Basic digital skills				
Basic operations	First, participants had to choose the correct options for entering special characters that were not included in the QWERTY keyboard (i.e. ®, ≤, α). In the second task, participants had to evaluate which clipboard statements were correct.	.44	.74	.56
Word processing	In the first task, participants had to choose from a list of options what modifications (paragraph and page formatting, header and footer) had been made to the text documents presented. In the second task, they had to choose from among a list of options how the desired modifications could be implemented (indexing, page numbering, and page break).	.63	.84	.56
Spreadsheets	Participants had to choose the right formula for the spreadsheet cell and, accordingly, the right function to solve the tasks presented. In addition, they had to select the appropriate formatting actions for formatting and ordering the cell content.	.45	.85	.55
Presentations	Participants had to select actions to achieve the desired features (how to insert background and bullets/numbering, and formatting charts and graphics) to the slideshows presented.	.47	.87	.55
Information seeking	Participants were required to select the best sources of information for specific situations, write an appropriate search query to a simulated web search engine for a given search situation, and evaluate and select relevant and reliable results for a given information need from the simulated 'search engine results page'.	.42	.42	.48
Social networking	Participants had to choose the most appropriate and safest option for social networking cases.	.44	.62	.37
Image processing	Participants had to choose how to implement desired formatting on images presented (brightness and colours, cropping the picture, and/or removing elements from the image).	.78	.63	.52
Web content creations	In the first task, participants had to choose from five html outputs the correct match for the given html code (a simple example containing text, link, input field, and font colours). In the second task, participants had to evaluate which claims about the (Finnish) exercise of freedom of expression in the mass media were correct.	.36	.78	.55
Advanced technical skills				
Operating system installation and initialisation	Participants had to evaluate which statements about operating system installation and initialisation were true.	.26	.59	.69
Software installation and initialisation	Participants had to evaluate which statements about software installation were correct and to choose from given options which operations were needed during the software installation.	.44	.83	.66
Maintenance and updating	Participants had to evaluate which statements about maintenance and updating of software were correct.	.39	.80	.67
Information security	In the first task, participants had to choose the correct	.33	.71	.58

	action/conclusion in the case where it turns out that a web service stores user passwords in a clear text format. In the second task, they had to choose which options were not proper information security methods.			
Information networks	In the first task, participants had to evaluate which statement about denial-of-service attacks was correct. In the second task, participants had to identify the information network techniques and match them with the presented network graph.	.37	.77	.72
Professional ICT skills				
Server environments	Participants had to choose the correct statements regarding logical volume management and hot swapping.	.14	.52	.71
Database operations	Participants had to select the correct SQL query for a given situation. In addition, they had to choose the correct description for the database schema presented.	.12	.45	.69
Digital technology	In the first task, participants had to choose the best match between the options and the presented graph on logic gates. In the second task, they had to choose on which area of mathematics digital technology is based on.	.11	.40	.59
Programming	In the programming tasks, participants had to select the correct description for a particular pseudo-code example and select the values of given variables after executing the code.	.16	.49	.65

P = Item difficulty index (optimal range between .2 and .8),
D = Item discrimination index (threshold value < .2),
r = item-total correlation (threshold value < .2),
Cronbach’s alpha of the entire scale .86 (threshold value < .7)

Appendix 2. The usage habit questionnaire items from the original ICT Skill Test and their categorisations for usage domains.

Item	**Economic use**	**Cultural use**	**Social use**	**Personal use**
Social networking services			x	
Video-sharing services		x	x	
Photo-sharing services		x	x	
Web blogging		x	x	
Internet discussion forums		x	x	
E-government services	x			
Online banking	x			
Online shopping	x			
Online newspapers	x			
Newsgroups	x			
Weather services	x			
E-mailing	x		x	
Instant messaging			x	
Voice/video chatting			x	
Video/computer games (in single-player mode)				x
Video/computer games (in multi-player mode)			x	x
Casual gaming				x
Search engines/information searching	x			
Web-mapping/route planning services	x			
Vertical directories	x			
Wikis	x			
Online dictionaries	x			
Watching TV-series online				x
Downloading/listening to music online				x
Downloading/watching films online				x

Word processing	x	
Spreadsheets	x	
Presentations	x	
Image manipulation/editing		x
Audio editing		x
Video editing		x
Computer graphics		x
Computer programming	x	
e-learning environments	x	

Appendix 3. The renewed ICT Skill Test test items and their categorisation, description and the results of item analysis.

Item	**Description**	***P***	***D***	***r***
Medium-related skills:				
Basic operations	Participants had to pair a keyboard shortcut with a correct action and select the correct type of computer memory for the particular situation.	.21	.61	.44
Installation and updates	In the first step, participants had to choose whether the statement refers to an installation or an upgrade, and in the second step, they had to choose whether the statement relates to an update or an upgrade.	.49	.85	.58
Information networks	Participants were given four network usage scenarios and had to pair them with the correct data transmission technologies and then match the correct descriptions of computer network-related concepts with given options.	.18	.47	.36
Word processing	Participants were asked to edit (bold, italicize, underline and highlight) the sample text presented.	.54	.99	.48
Spreadsheets	Participants were asked to fill in the spreadsheet with the information provided, to bold the title row, and to sort the table in ascending order.	.29	.73	.52
Presentations	Participants were given a general user interface view of the presentation software. The task was to match the named functions with the right parts of the image.	.31	.80	.52
Content-related skills				
Social networking	Participants had to pair the correct social networking services with the service descriptions, define the meaning of social networking service, and select the correct alternatives related to the security of social networking services.	.41	.64	.60
Communications	Participants had to complete the e-mail receiver fields (carbon copy and blind carbon copy) and add an attachment according to the instructions provided, and identify the types of information that can be used to identify Internet users.	.46	.80	.66
Information security	Participants had to choose the correct statements for secure network communications and choose from given alternatives those that related to the security of the computers in a foreign Internet cafe.	.43	.74	.65
Image processing	Participants had to select the correct image processing tools for cropping the image presented and making the person appearing in the image unrecognizable. Afterwards, participants had to choose the correct image processing statements from the options and select the correct file formats for vector graphics.	.33	.58	.59
Video and audio processing	First, participants had to choose the methods that can be used to edit video footage from a single camera, and then choose the correct answer to the question, “Which one of these alternatives is related to lossy audio compression?”.	.44	.82	.64
Cloud services and publishing	In the first phase, participants had to choose which statements about the cloud services were true. In the second step they had to choose the correct YouTube-video sharing option that allows	.44	.90	.58

	limited sharing even for those who do not have an account on YouTube. The third phase was the follow-up question: “Can we now be sure that the video will not spread to the rest of the Internet for outsiders to see [...]?”			
Software purchasing	Participants had to choose what to consider when evaluating the security of mobile applications, and select the correct definition of personal data protection.	.22	.52	.48
Information seeking	Participants had to select the correct source/channel to look for more information on the topic presented. After this, they were presented with list of search engine results and were asked to select relevant and reliable results related to the given scenario.	.63	.55	.39
Programming skills:				
Elementary programming	Participants were required to write, per instructions (i.e., L = 90 degrees to the left, F = one step forward...), a maze traversing script that leads from the starting point to the end. After this, they were presented with a short pseudo-code and they had to write the value of a given variable after executing the given code.	.09	.30	.43
Database operations	Participants had to form an SQL-query based on instructions and a simple database schema provided, and then choose the correct definition for the term ‘NoSQL database’.	.05	.17	.21
Web programming	Participants were presented with three files (HTML, CSS and JavaScript) and the view generated by these files. Participants had to select the right answer to the questions on how to edit the simple web page view and what were the dependencies between these given files.	.08	.28	.26
Programming	The programming task required the participants to place Java code lines in the correct places based on the comment sections provided.	.01	.04	.25

P = Item difficulty index (optimal range between .2 and .8),
D = Item discrimination index (threshold value < .2),
r = item-total correlation (threshold value < .2),
Cronbach’s alpha of the entire scale .87 (threshold value < .7)

Appendix 4. The usage habit questionnaire items from the renewed ICT Skill Test and their categorisations for usage domains.

Item	**Economic use**	**Cultural use**	**Social use**	**Personal use**
Maintaining social relationships			x	
Commercial use	x			
Following current events	x			
Communication			x	
Game playing			x	x
Information seeking	x			
Digital entertainment				x
Creating digital content		x		
Sharing content online		x	x	
Learning	x			

Original Publications

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Performance-based Testing for ICT Skills Assessing:
A Case Study of Students and Teachers' ICT Skills in Finnish Schools

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LONG PAPER

Performance-based testing for ICT skills assessing: a case study of students and teachers' ICT skills in Finnish schools

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Abstract Skills enabling and ensuring universal access to information have been investigated intensively during the past few years. The research results provide knowledge on the differences and digital divides. When examining ICT skill levels, the accuracy of assessment is one of the key issues to address the results and gain the applicable data for appropriate interventions to enhance digital inclusion. To date, ICT skill assessment is based mainly on self-reports and subjective evaluations. However, as previous studies have shown, people tend to overrate or underrate their own levels of competence. Thus, novel performance-based approach for assessing ICT skills is presented in this paper. The ICT skill test contains 42 tasks grouped into 17 ICT fields. The study was conducted with upper comprehensive and upper secondary level school students ($n = 3159$) and their teachers ($n = 626$) during years 2014–2016 in Finland. Using factor analysis, three ICT skills factors were created: basic digital skills, advanced technical skills, and professional ICT skills. The performance in the ICT skill test was also divided by gender, as the male students and teachers outperformed the female students and teacher. Outperformance also occurred by educational level, as both upper secondary level students and teachers were seen as possessing higher-level ICT skills than students and teachers at the comprehensive level. We thus argue that to compare the ICT skills and the validity of the assessments, we needed to ensure consistent assessment for both students and teachers. In addition, in order to diminish the ICT skill gap among students, interventions using formal education are urgently needed, and in particular, more attention should be given to both teacher training and in-service training.

Keywords Skill assessment · ICT skills · Digital divide · Formal education

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1 Introduction

During the past few years, universal access to digital information has received a lot of attention, as sufficient ICT skills can enable citizens to utilise certain key services in digitalised societies [1–4]. Consequently, ICT skills are important for educational systems and strategies when avoiding digital gaps citizens' exclusions from basic services in society and when ensuring universal access to information, see [5, 6]. An open question, however, still remains what these essential skills in digital societies actually are. In the DIGCOMP framework project funded by the European Commission to develop and understand digital competence, five competence areas were categorised, namely information, communication, content creation, safety, and problem-solving competencies [6]. In turn, Binkley et al. [7] defined twenty-first century skills as ways of thinking, working, and living in a digitalised world. Further still, Fraillon et al. [8] defined computer and information literacy as the 'individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in the society' (p. 17). Consequently, the skills related to information and communication technology seem to be ever more important for citizens to have in their lives. Quite often, research on universal access to information turns into discussions on digital divides. Research on the digital divide and digital inclusion has moved during the past few decades from issues of availability and access of technology to research on the skills, and further yet to the actual outcomes of Internet and digital technology use [9, 10].

To analyse how to enhance digital inclusion using education, accurate knowledge of the level of current digital skills and competencies is needed. However, there are several challenges for the instruments currently available for assessing ICT skills, namely a conceptual ambiguity in the definitions and the operations of the assessment methods and the tendency of many of the instruments used oversimplify ICT skills [11–13]. To date, ICT assessments are often based on self-reporting and subjective evaluations [11]. Yet, as previous studies have shown, when people are making self-reports on skill assessments, they too easily overrate or underrate their levels of competence, see [12–14]. Therefore, an alternative approach for investigating the current levels of ICT competencies was employed here.

This paper reports the results of performance-based ICT skills assessment for both students and teachers. In order to improve education and ICT competencies in schools, assessments of both students and teachers' skills are needed. Hence, we investigate the differences between the three factors of ICT competence regarding basic, advanced, and professional ICT skills. The ICT skills test used contained 42 performance-based items, which was then categorised into 17 fields of ICT skills (see Appendix 1). These 17 fields are based on the Finnish National Core Curriculum [15], the content of the eSkills certification programmes of the Finnish Information Society Development Centre, and the requirements of information and communication studies in Finnish universities of applied sciences.

We thus addressed the following research question:

> How do students and teachers perform in the ICT skill test by gender and educational level and which kind of differences are there between the ICT skills of students and teachers?

This paper contributes to universal access research that can provide empirical results on how ICT skills assessment is constructed and conducted for both students and teachers. In this study, we evaluated ICT skills using three factors and the results identify the differences among and between the ICT skills of students and teachers. By using the same performance-based test for assessing ICT skills for students and teachers, the results and conclusions offered on how to enhance digital inclusion through education are more accurate than the results from only self-reported evaluation.

2 Digital divides compared to digital skills

The goal, which is to ensure universal access to information and thereby diminish digital divide, in recent studies has shifted its focus on these digital divides from limitations in access and availability of technology to differences in technology use and actual skills [1, 16] and even further to examine the differences in the benefits gained from Internet and technology use across all life realms [9]. In the 1990's, primary attention was paid to inequalities in the availability of technology and Internet access in various countries. These considerations were strongly related to such issues as socio-economic background, race, and residence [10, 16]. This phase was called the first level of the digital divide.

Then, at the beginning of the 2000's, the focus on digital divide research shifted to examine actual differences in skills and usage. When more people did gain access to the technology infrastructure, their skills and usage habits became the focus of research, and insufficient skills were noticed as playing a major role actual digital inclusion [17, 18]. This phase became known as the second-level digital divide [17].

In their study, van Deursen and van Dijk [18] pointed out that even though low-level educated individuals spent more hours and visited the Internet more frequently than medium- and high-level educated people, these lower educated people did not benefit as much from being online as the more educated people did. Low educated people tended to engage mainly in social interaction and gaming, quite time-consuming activities. Higher educated users tended to consume the Internet less in terms of time, though they used it in more beneficial ways and uses. For example, they used the Internet for personal development, information seeking, and following the news. Consequently, highly educated people tended to use Internet in ways that helped their knowledge and skills increase while low educated users did not. It was then argued that Internet usage habits can reflect known socio-economic differences, and thereby, Internet use could tend to reinforce rather than decrease social inequality, see, e.g. [9, 17].

The third level of the digital divide concerns the differences in tangible outputs that users gain from Internet use within certain populations that have broadly similar usage profiles and relatively autonomous and unlimited access to both the Internet and ICT infrastructures. In other words, the issue relates to gaps in users' capacity to translate their time online into favourable offline outcomes. Research on this third-level divide examines who benefits and in what ways from Internet use [9]. In a societal context where Internet access is nearly universal, researchers have now detected various feedback effects. For example, outcomes achieved from the Internet use provide useful feedback on people's offline status, which in turn influences digital inclusion factors as access, skills, use, and motivation, see, e.g. [1, 9]. When van Deursen and Helsper [9] examined the outcomes of digital engagement, their results showed that most of the digital divide indicators related to first of all skills and then their Internet usage patterns. Further still, highly educated individuals benefited more from being online than did less educated people, particularly in the domains of commerce, institutional government, and educational outcomes. The overall conclusion offered by van Deursen and Helsper [9] was that, although more and more people have gained access to Internet, entity offers the most to the higher socio-economic groups. Therefore, when information and services are increasingly offered online, the number of potential outcomes of such digitalisation increases. As people from higher socio-economic group achieve better offline benefits from their digital engagement than people of lower status, inequalities in society may also increase.

According to van Deursen and Helsper [9] in societies with near-universal Internet access, such as the Netherlands (or the Scandinavian countries, including Finland), the third-level digital divides have become crucial. This issue is a challenge for formal education practices as well. As Hatlevik et al. [19] pointed out, schools should identify their students' level of competence and make distinct plans to equalise these observed ability differences. Further, in terms of the school's role in developing their students' ICT skills, Kivinen et al. [3] stated:

> "According to policy-makers, school should prepare would-be citizens for the knowledge society by teaching ICT-literacy, knowledge-assessment, and skills of digital communication and cooperation. Yet at the moment not all teachers have proficiency in ICT themselves, pupils' skills vary greatly, and many of the established school practices may not be smoothly compatible with the new objectives of the professed information society" (p. 377).

According to Goode [20], educational institutions have thus far also offered digital learning opportunities quite heterogeneously.

3 ICT skills evaluation

3.1 Concepts

According to Siddiq et al. [11], the concepts and constructs for ICT skill assessment should be conducted from either a domain perspective (ICT, digital, or twenty-first century) or a knowledge perspective (literacy, competence, and related skills). In their systematic review, Siddiq et al. [11] examined 38 assessment instruments for primary and secondary school students' ICT literacy from years 2001 to 2014. Their review compressed the main dimensions from different studies to those related to information, communication, content creation, safety, problem-solving, and technical operational skills. The information dimension contains issues such as browsing, searching, filtering, evaluating information, storing, and retrieving information. Communication references interact through digital technologies, sharing information and content, engaging in online citizenship, and collaborating through digital technologies. Content creation includes developing content, integrating and re-elaborating it, copyright and licences, and computer programming. Safety involves protecting devices, managing and protecting personal digital data, protecting health, protecting the environment, and 'net' etiquette. Problem-solving in turn involves resolving tasks by using digital tools, collaborative problem-solving, innovating and creatively using technology, and identifying digital competence gaps. Finally, technical operational skills include the ability to solve technical problems, identify needs and technological responses, and use basic technical skills. [11].

Ferrari's [6] DIGCOMP framework quite similarly divides digital competence into information skills, communication skills, content creation skills, safety skills, and problem-solving skills. Information skills include browsing, searching, filtering, evaluating, storing, and retrieving information. Communication skills include interacting, sharing, engaging, collaborating, net etiquette or 'netiquette', and managing digital identity. Content creation skills in DIGCOMP are identical to the review of Siddiq et al. [11] already mentioned here. Safety skills in DIGCOMP refer to protecting devices, data and digital identity, health, and the environment. Problem-solving skills in turn include solving technical problems, identifying needs and technological responses, innovation and creative technology use, and identifying digital competence gaps [6]. Van Deursen et al. [14] indeed remarked that Ferrari's definitions are technically oriented and based on the number of devices used for online communication.

Helsper and Eynon [21] identified four distinct types of digital skills: Creative, social, technical, and critical. Their goal was to bring two important, but usually separate areas of study together: research on digital skills and literacy and research on the effective use of ICTs under the digital inclusion agenda. Creative skills based on their approach consist of uploading photographs, downloading music, and learning to use a new technology. Social skills in turn include participating in discussions online, making new friends, and uploading photographs. Technical skills involve cleaning up viruses, participating in discussions online, and learning to use a new technology. Finally, critical skills involve judging the reliability of a source and gathering information. Helsper and Eynon also [21] pointed out that social and creative skills are more activity than skills related. Van Deursen et al. [14] continued Helsper and Eynon's classification by stating it was based on media literacy research, which suggested that skills should be evaluated beyond the mere technical level and instead as those skills relate to the ability to work with technologies for specific social purposes.

The Internet Skills Scale (ISS) designed by van Deursen et al. [14] measures five dimensions of Internet skills: operational, navigation information, social, creative, and mobile. Van Deursen et al. [14] argued that Internet skills should be considered distinct from computer skills since the use of the Internet requires more skills than the use of a computer. For example, information searching or content creation requires more than just the skills to use a computer. The operational factor of ISS contains, for example, abilities to download and save files, use shortcut keys, connect to a WIFI network, and adjust privacy settings. Information navigation skills include the abilities to decide the best keywords for online searches or the skills to navigate through web pages. The social factor of ISS includes the ability to know which information to share online or how to limit the audience on social media. The creative factor contains skills, such as how to create something new from existing online content, how to design a web page, and the knowledge for how to apply online content licences. The mobile factor in turn includes the ability to install or download apps and keep track of the costs of actual mobile app use.

When these assessments are conducted in the context of formal education, the results of ICT skill assessment are often desired to be applicable to the national curriculum development [22] or for school-level planning [5]. In addition, most of the research is often conducted with student samples, such as secondary or high school students [23, 19], university students [24], or teenagers in general [2]. Quite a few of the studies (see, e.g. [5, 13]) have assessed teachers' ICT skills.

3.2 Assessment methods

There are a variety of methods used to conduct and evaluate ICT skill assessments, though surveys and self-reports seem to be the most dominant methods. In her review of Internet skill measurements and their assessments, Litt [25] classified Internet skill assessment methods into: (1) survey and self-reported measures, (2) performance/observation measures, and (3) combined and unique assessments. In surveys and self-reports, the dominant methods in the field of Internet and technology skill assessment, participants usually respond to a question or a set of questions about their own competence levels (e.g. [25, 2]) or evaluate their ability to perform specific tasks on the Internet (e.g. [18, 26]). In the second type of assessment method (according to Litt's classification [25]), qualitative studies prefer observation-based measures or interviews, which incorporate ethnographic or practices. These types of studies have focused on, for example, observing a person's actions during information search tasks [27, 28]. Interviews in their turn typically consist of open-ended questions like 'What are you strong in?' [3]. Litt [25] also argued that the majority of observation and performance Internet skills studies have a structure that reminds one of laboratory-like settings.

Task-based assessments are more unusual than assessment methods are, based on self-evaluations when evaluating ICT skills. Some studies have conducted a task-based assessment in which participants performed, for example, Internet tasks related to a holiday trip abroad [29] or government issues [28]. Claro et al. [22] developed a task-based assessment in their own virtual environment by simulating an actual environment where ICT skills are typically used. This virtual environment simulated common ICT applications and the tasks that were designed emulated real-life school work situations. The problems and tasks the participants solved in this assessment environment related to information, communication, ethics, and their social impacts. Moreover, Ainley et al. [5] used a similar task-based test design in their assessment instrument questions and for their tasks based on a realistic theme, and these followed a linear narrative structure. However, as Litt [25] summarised, performance- and observation-based measures do have challenges due to their time-consuming nature and the difficulties of cross-comparison and replication. Self-reports were criticised for their validity because of thee evaluations being subjective. Further, Van Deursen et al. [14] argued that because performance measurements are time-consuming and expensive, there is an urgent need for more accurate and reliable large-scale assessment instruments and more valid, updated, and nuanced self-assessments to have more generalisable and diverse samples.

To summarise, when comparing the assessment methods, the majority of assessment instruments use self-reporting. Most are online tests with multiple choice questions. Some have also included dynamic formats that require participants to interact with the tasks. A few were comprised of a dynamic task design that required some interaction with the test environment. The majority of tests are evaluated using quantitative methodologies [11]. In addition, Siddiq et al. [11] argued that the majority of the tests assess digital information search, retrieval, evaluation, and technical skills, though aspects like problem- solving with ICT, digital communication, and online collaboration are not covered to satisfaction. They also argued that there is a lack of documentation of the psychometric properties for many of the assessment instruments [11]. In the context of our study, Finnish basic education and secondary education level teachers' ICT skills and practices have previously been investigated using a self-report questionnaire [30] and a teacher online survey called OPEKA [31]. The OPEKA group has currently developed a corresponding online survey (OPPIKA) for students. Therefore, we argue that performance-based assessments are indeed needed.

4 Research method, procedure, and data

In our study, student data were collected in Finland during the years 2014 and 2015. Altogether, 41 upper comprehensive and upper secondary level schools were chosen for convenience sampling, i.e. these schools were able to choose whether they wanted to be involved in the study or not. The students from the basic education level (grades 7–9/9) were tested one class at a time, so any bias caused by self-imposed participation was as slight as possible. Altogether, 3159 youths from 12 to 22 were tested, and of those, 51.6% were boys and 48.4% were girls. The mean age of the participants was 15.85 years. Further, 40% ($N = 1261$) of the students came from the basic education level (upper comprehensive schools, grades 7–9), and 60% ($N = 1898$) from the upper secondary level. In the Finnish education system, the upper secondary level is divided into general (leading to the matriculation examination) and vocational (leading to a vocational examination). Commonly, admission to higher education is based on the results of the matriculation examination and/or entrance tests, although both of the upper secondary level choices provide an opportunity to continue to the tertiary education level [32]. Of the upper secondary level students in this study, 54% came from general upper secondary schools, and 46% from vocational institutions.

Teacher data were collected in Finland during the years 2014–2016. The participating educational institutions could choose whether to test only students or also test teachers. The acceptable response rate among teachers from those organisations that elected to join was 70%. All organisations for which the response rate remained below that level were removed from the final data. Altogether, 626 teachers from the basic education level (comprehensive schools) and the upper secondary education level (general upper secondary schools) were tested, and of that total, 29.5% were male teachers, and 70.5% were female teachers. The mean age of these participants was 45.04 years (min 25, max 65). Among the teacher data, 78% ($N = 490$) of teachers came from basic education level schools, and 22% ($N = 136$) came from general upper secondary schools.

ICT skills were measured using the digital, performance-based ICT skill test. The test was the same for both the students and the teachers. Altogether, the test consisted of 42 task-based items, grouped into 17 fields of ICT skills (see Appendix 1). Tasks were implemented in such a way that the context (user interface, graphics) simulated common ICT applications and hence mirrored real-life settings. Each field contained 2–5 items, and the participants could achieve 4 points in each field, which could result in a maximum total score of 68 for the ICT skill test.

The tested competence areas (17 fields) were chosen based on the Finnish National Core Curriculum [15] current at the time of test development, the content of eSkills certification programmes (intended for working adults) for the Finnish Information Society Development Centre, and based on the requirements in the information and communications technology field at the universities of applied sciences. To ensure that these items were well understood by all potential respondents, a usability testing was conducted with upper comprehensive school students during the software development process during the fall of 2013.

5 Dimension of ICT skills of students and teachers

As a preliminary analysis, we conducted exploratory factor analyses to assess the construct validity of the scales used in our study. We used the principal components factor analysis with a varimax rotation to assess the factor loadings and dimensionality of our scales as well as to refine the measures. The factor analysis was conducted using the student data.

Before the exploratory factor analysis, we performed Bartlett's test of sphericity to investigate factorability of the data, and Kaiser–Meyer–Olkin's (KMO) test to measure sampling adequacy. These results indicated a significant test statistic for Bartlett's test of sphericity, Chi-square 14,397.196, *df* 136, $p \leq .001$, and a KMO value of .927, meaning that the data were suitable for structure detection.

The exploratory factor analysis of the data, using the principal component extraction method and a varimax rotation of all the 17 items, revealed three factors with eigenvalues over 2.0 (see Table 1). The first factor, 'basic digital skills', with an eigenvalue of 3.35, included eight items (Cronbach's alpha = .81). The second factor, 'advanced technical skills', with an eigenvalue of 2.74, included five items (Cronbach's alpha = .75). The third factor, 'professional ICT skills', with an eigenvalue of 2.22, included four items (Cronbach's alpha = .66).

Table 1 Rotated factor component matrix for the ICT skills test fields

	Factors		
	1	2	3
Factor 1: basic digital skills			
Word processing	.730		
Spreadsheet	.673		
Social networking	.660		
Information seeking	.656		
Presentation	.607		
Basic use of computers	.535		
Image processing	.508		
Web content creation	.487		
Factor 2: advanced technical skills			
Operating system installation and initialisation		.718	
Maintenance and updating		.691	
Software installation and initialisation		.680	
Information security		.571	
Information networks		.552	
Factor 3: professional ICT skills			
Server environments			.745
Database operations			.730
Digital technology			.664
Programming			.551
Eigenvalue	3.35	2.74	2.22
Variance explained	19.72	16.13	13.07
Cronbach's alpha	.81	.75	.66

This three-factor solution explained 49% of the total variance, and the Cronbach's alpha of the entire scale was .86. This outcome provided support for conceptualising the total ICT skills as a construct with the presented three subscales. However, because the values of .7 or .75 are often the 'cut-off' value for Cronbach's alpha, see [33], at least the third factor should be considered as regenerating in the future in order to heighten its reliability estimate. Eventually, all the item loads based on the exploratory factor analysis were at least .49 or greater, which was a sign of their practical significance.

The factor scores were normalised by dividing the factor sums by the number of factor items to enable clear comparisons between the factors. After normalisation, the range for each factor was 0–4 points. For the student data, the average score on the basic digital skill factor was 1.995 out of 4 points, with a standard deviation of .787. The average score on the advanced technical skill factor was notably lower at 1.432, with a standard deviation of .867. Obviously, the most difficult factor for students was professional ICT skills, for which the average score was .657, with a standard deviation of .53. The means and standard deviations for the average scores for each ICT skill factor are shown in Table 2. Likewise, for the teachers, the average score on the basic digital skill factor was 2.331 out of 4 points, with a standard deviation of .812. The average score for the advanced technical skill factor was 1.595, with a standard deviation of 1.063. The professional ICT skills had an average score of .371, with a standard deviation of .530, which was even lower than that for the students' performance for the same factor.

To examine the differences between the students and the teachers for the three factors of the ICT skill test, the analyses of variance (ANOVA) were utilised (see Table 2). In basic digital skills and advanced technical skills, teachers performed significantly better than the students (basic digital skills: $F = 95{,}729$, $df = 1$, $p \leq .001$, advanced technical skills: $F = 17{,}951$, $df = 1$, $p \leq .001$). For professional ICT skills, the students in their turn outperformed the teachers, and this difference was found to be significant ($F = 30{,}325$, $df = 1$, $p \leq .001$).

5.1 ICT skills by gender

To examine whether there were any gender differences for the three factors of the ICT skill test, an analysis of variances (ANOVA) was conducted comparing the factor scores between the male and the female students (see

Table 2 Means and standard deviations for the average scores for ICT skill factors

ICT skill factor	Students		Teachers		The one-way analysis of variance (ANOVA)		
	M	SD	*M*	SD	*F*	*df*	*p*
Basic digital skills	1.995	.787	2.331	.812	95,729	1	.000**
Advanced technical skills	1.432	.867	1.595	1.063	17,951	1	.000**
Professional ICT skills	.657	.530	.371	.530	31,325	1	.000**

** $p \leq .001$

Table 3 ICT skills and gender differences for students

ICT skill category	Female students		Male students		The one-way analysis of variance (ANOVA)		
	M	SD	*M*	SD	*F*	*df*	*p*
Basic digital skills	1.959	.766	2.025	.803	5694	1	.017
Advanced technical skills	1.189	.771	1.653	.886	245,111	1	.000**
Professional ICT skills	.352	.520	.696	.723	234,537	1	.000**

** $p \leq .001$

Table 4 ICT skills and gender differences for teachers

ICT skill category	Female teachers		Male teachers		The one-way analysis of variance (ANOVA)		
	M	SD	*M*	SD	*F*	*df*	*p*
Basic digital skills	2.241	.782	2.550	.845	19,243	1	.000**
Advanced technical skills	1.331	.945	2.234	1.066	109,592	1	.000**
Professional ICT skills	.246	.501	.675	.881	58,941	1	.000**

** $p \leq .001$

Table 3) and also between the male and the female teachers (see Table 4). Among the students, the average scores of male students were discovered to be higher than the average scores of female students, though for basic digital skills, the difference was not significant ($F = 5694$, $df = 1$, $p > .01$). Instead, the significant differences in advanced technical skills ($F = 245{,}111$, $df = 1$, $p \leq .001$) and professional ICT skills ($F = 234{,}537$, $df = 1$, $p \leq .001$) were discovered by examining for gender. On the contrary, among the teachers, we discovered significant differences in all ICT skill factors (basic digital skills $F = 19{,}243$, $df = 1$ $p \leq .001$, advanced technical skills $F = 109{,}592$, $df = 1$, $p \leq .001$, professional ICT skills $F = 58{,}941$, $df = 1$, $p \leq .001$), with male teachers being more skilled in all three factors than females were.

5.2 ICT skills by educational level

The analysis of variance (ANOVA) was utilised in the analysis of educational level differences for the three factors of ICT skills. Because there were three different education levels contained in the student data, the *p* values from ANOVA were adjusted using the Bonferroni correction for multiple comparisons. Among these students, there were significant differences for educational levels in all factors of the ICT skill test (basic digital skills $F = 232{,}871$, $df = 1$, $p \leq .001$, advanced technical skills $F = 86{,}217$, $df = 1$, $p \leq .001$, and professional ICT skills $F = 17{,}268$, $df = 1$, $p \leq .001$) (see Table 5). The paired comparison indicated that in the case of basic digital skills, all educational levels differed significantly from one another, with the comprehensive school students being the weakest and the general upper secondary school students performing the best. For advanced technical skills, the basic education students performed significantly weaker than the upper secondary level students did, and in professional ICT skills, students from the vocational institutions significantly outperformed other education level students.

Accordingly, in the teacher data (see Table 6) for all ICT skill factors, upper secondary level teachers were found to perform significantly better than basic education level teachers (basic digital skills $F = 9650$, $df = 1$, $p \leq .01$, advanced technical skills $F = 18{,}459$, $df = 1$, $p \leq .001$, professional ICT skills $F = 11{,}712$, $df = 1$, $p \leq .01$).

Table 5 ICT skills and educational level for students

Factor	Basic education		Upper secondary education				The one-way analysis of variance (ANOVA)		
	Comprehensive schools (grades 7–9/9)		General upper secondary schools		Vocational institutions				
	M	SD	*M*	SD	*M*	SD	*F*	*df*	*p*
Basic digital skills	1.683	.724	2.348	.714	2.026	.770	232,872	2	.000**
Advanced technical skills	1.187	.832	1.604	.841	1.570	.856	86,217	2	.000**
Professional ICT skills	.458	.634	.536	.634	.625	.698	17,268	2	.000**

** $p \leq .001$

Table 6 ICT skills and educational levels for teachers

ICT skill category	Basic education		Upper secondary education		The one-way analysis of variance (ANOVA)		
	M	SD	*M*	SD	*F*	*df*	*p*
Basic digital skills	2.279	.801	2.522	.827	9650	1	.002*
Advanced technical skills	1.500	1.030	1.937	1.114	18,459	1	.000**
Professional ICT skills	.321	.607	.542	.822	11,712	1	.001*

** $p \leq .001$

* $p \leq .01$

6 Conclusions and discussion

Research in digital inclusion has developed further and shifted its focus during the last decade. Digital skills have been recognised as an important aspect of success in highly digitalised societies, and correspondingly the need of assessing those skills has increased. Available instruments for ICT skill evaluation, however, have generally been insufficient. This paper reports a study on performance-based ICT skill assessment in the context of formal education for 3159 students and 629 teachers during the years 2014–2016.

After a preliminary factor analysis, three ICT skill factors were formed. The first factor, basic digital skills, consists of basic operational, content creation, and information searching skills. As expected, both students and teachers performed best in basic ICT skills. The second factor, advanced technological skills, consisted of more technical issues such as software and operating system installation and initialisation and maintenance and updating as well as the issues of information networks and security. Both students and teachers tended to gain notably fewer points from tasks belonging to this factor than those belonging to the previous factor. Worth noticing was that male teachers performed better on the first and second factors than did students, and the performance of female teachers in the first factor was better, although for the second factor weaker than for students. The third factor, professional ICT skills, included those skills needed for tertiary educational level studies (in the ICT field) in Finland. For both students and teachers, this factor was clearly the most difficult, and only a few participants resolved the tasks for this factor with high credits. It is worth noticing as well that for this factor students were found to perform noticeably better than both female and male teachers.

The previous study by Gui and Argentin [23] pointed out that Italian high school students (aged 15–20) performed best on basic operational skills, when that study investigated their digital skills in theoretical, operational, and evaluational domains. In a study of 15-year-old Chilean students, Claro et al. [22] found that students were able to solve tasks related to the use of information as consumers (i.e. searching, organising, or managing information), though struggled with tasks that related to the use of information as producers (i.e. developing their own ideas in a digital environment, refining digital information, or creating representation). Calvani et al. [34] argued that based on their results, students' (aged 14–16) knowledge and competences were inadequate, especially when shifting from strictly technical aspects to critical cognitive and socio-ethical dimensions that were involved in the use of technologies. Van Deursen et al. [9] reported similar results among the Dutch for ages 16 to over 60; these people tended to manage basic operational (and communication) tasks, but had shortages, especially in their ability to use technology for creative purposes as information producers.

Our results in the current effort show that among the students studied, gender did not relate to significant differences in basic digital skills. For the tasks related to advanced technical skills and professional ICT skills, male students performed better than female students. The gender difference noticed among students in ICT skills test performance fell in line with previous research [35–37]. Overall, performance in ICT skills testing was highly divided by gender and more general among all students. Our results confirm the previous findings, namely that young people's technology skills are rather heterogeneous (see, e.g. [34, 38], and the hypothesis stating that young people are called 'digital natives' is not supported [38, 21]. Male teachers significantly outperformed female teachers in every ICT skill factor [37]. The observed gender differences among the teachers in our analysis are in line with Ilomäki's [37] research that found that male teachers estimate their ICT skills as being higher than female skills. Furthermore, examining the gender differences between teachers and students, our research found that the basic ICT skills of Finnish students are more equally distributed by gender than are the same respective skills of their teachers.

As expected, educational level was found to be related to ICT skills. Based on our data, the students in general upper secondary schools and in vocational institutions had better test results than comprehensive school students. This finding is mainly due to the simple fact that upper secondary level students are older than comprehensive school students. However, there also existed differences among upper secondary level students, even though these students were coevals. General upper secondary school students outperformed students from vocational institutions in basic digital skills and advanced technical skills. To the contrary, students from vocational institutions performed better on professional ICT skills. Therefore, not only age, but also the field of education, and differences in students' interests, affected students' ICT skills. Respectively, among teachers, upper secondary school teachers gained better results on all three ICT skill factors when compared to the other teachers.

With respect to gender and educational level differences among the teachers, it should be noted that in Finland all teachers, in both basic education level and upper secondary level education, are required to have a Master's degree. Teachers in grades 1–6 in the basic education level are called class teachers (teaching de facto all subjects) and are required to have a Master of Education degree, and teachers in grades 7–9 at the basic level and all teachers in the upper secondary level are required to have both the Master's degree in the applicable field of study depending on the subject(s) they are teaching and in pedagogical studies. In our teacher data, the effective size of the gender difference was equal among teachers of grades 7–9 and upper secondary level, although there did exist differences for teachers' teaching areas, and among those teachers of grades 1–6 (class teachers), where all teachers have the same educational background and the same teaching area. Thus, among the teachers, the differences in ICT skills were more likely the consequence of differences in motivation, (leisure time) digital technology usage experience, and the professional requirements of different education level institutions than the consequence of other issues like academic background or teaching area.

Obviously, these findings also relate to in-service training and the interventions and staff development efforts that need to be made for all teachers to improve their ICT skills and thus ensure optimal digital skill learning opportunities for every student in the Finnish schools. According to PISA 2012 in Finland, the amount of teachers who report a high level of need to develop their ICT skills for teaching is 17.5%, which is less than in OECD countries average [39]. Weaknesses in teachers' pedagogical ICT skills may have been seen, but the extent of that of the problem is not still fully realised.

We should also note that in a rapidly digitalising world, digital services will be used and digital information accessed everywhere in society. ICT skills can be learned by using social media, playing mobile games, seeking information, and running daily errands using the Internet. Therefore, in addition to informal learning, formal education should help ensure the ability to survive in a digital society and let every citizen benefit from digital engagement for in the future. It is very likely that the challenge is that computer science or information technology is not currently an independent subject at the comprehensive or upper secondary level education in Finland. Consequently, there are no such teachers in the schools, whose main responsibility is the teaching of ICT skills. Instead it becomes the responsibility of every teacher. That is why strengthening all teachers' ICT skills and narrowing existing skill gaps between all teachers is essential when seeking to obtain equal digital learning opportunities for every student at all the educational levels.

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Appendix 1

Field	No. of items	Type of item	Description of items
Basic operational skills	2	Multiple choice	There were two tasks. First, the participants had to choose between seven alternatives, namely the right answers (2) to the question: 'How do you type special characters, which are not included in the QWERTY keyboard (i.e. Θ, ¾, ¥, ∉)'. In the second task, participants had to choose, between seven alternatives, namely which items were the correct answers to the question: 'Which two statements about the clipboard are correct?'
Information seeking	5	Multiple choice and open-ended questions	Participants had to choose between four alternatives, namely the best information sources for the given situations (all together three tasks), from a search query for a 'web search engine' (Task 1), and how to evaluate and choose relevant and reliable outcomes for a given problem from the 'search engine results page' (Task 2)
Word processing	2	Multiple choice (matching)	In the first task, participants had to choose between five alternatives for what modifications (paragraph and page formatting, header and footer) were presented for the text documents. Then, similarly in the second task, they had to choose, between five alternatives for the desired modifications to implement (indexing, page numbering, and page break)
Spreadsheets	3	Multiple choice (matching)	Participants had to choose between four alternatives for the right formula for the spreadsheet cell, and similarly, between four alternatives, for the right function to solve the presented task. In addition, they needed to choose between five alternatives for the appropriate formatting actions to implement (formatting and ordering of cell content)
Presentations	2	Multiple choice (matching)	Participants had to choose between four alternatives for the best implemented actions to take on the presented slide shows (by inserting background and bullets/numbering, formatting charts and graphics) (two tasks total)
Image processing	2	Multiple choice (matching)	Participants had to choose between five alternatives for the best implemented formatting actions to present images (for formatting brightness and colours, cropping the picture, and/or removing elements from the image)
Social networking	4	Multiple choice (case examples)	Participants had to choose, between four alternatives for the most appropriate and secure option for the social networking case (four tasks)
Web content creation	2	Multiple choice (matching)	In the first task, participants had to choose from five html outputs the correct match for the given html code (a simple example containing text, link, input field, and font colours). In the second task, participants had to choose between seven alternatives for the correct answer to the question: 'Which two statements about the (Finnish) exercise of freedom of expression in the mass media are correct?'
Software installation and initialisation	2	Multiple choice	Participants had to choose between seven alternatives for the right answers to two questions: 'Which two statements about (options for installation, and installation of media in) software installation are correct?' and between the four alternatives for the question 'Which statement about (operations needed during the) software installation is correct?'
Operating system installation and initialisation	2	Multiple choice	Participants had to choose between four alternatives for the right answers to the questions: 'Which statement about operating system installation and initialisation is correct?' (two tasks)
Maintenance and updating	2	Multiple choice	Participants had to choose between seven and four alternatives for the right answers to the question: 'Which statement(s) about maintenance and updating are/is correct?' (two tasks)
Information security	2	Multiple choice	In the first task, participants had to choose between four alternatives for the correct action/conclusion in the case where web service store user passwords in a clear text format. In the second task, they had to choose, between seven alternatives for which two options were not proper information security methods
Programming	4	Multiple choice	In the programming tasks, participants needed to choose between four alternatives to answer what the given code examples (2 pseudocode examples) does, and what were the values of these variables after running (2 questions)

Field	No. of items	Type of item	Description of items
Database operations	2	Multiple choice (matching)	Participants had to choose between four alternatives for the correct SQL query for a given situation. In addition, they had to choose between four alternatives for the correct description for the presented database schema
Information networks	2	Multiple choice (matching)	In the first task, participants had to choose between four alternatives for the right answers to the question: 'Which statement about denial-of-service attack is correct?' In the second task, participants had to recognise information network techniques and then choose the correct match from four alternatives for the presented network graph
Server environments	2	Multiple choice	Participants had to choose between five and four alternatives for the correct statements regarding logical volume management (Task 1) and hot-swapping (Task 2)
Digital technology	2	Multiple choice (matching)	In the first task, participants had to choose between six alternatives for the best match for the presented graph on logic gates. In the second task, they had to choose between five alternatives for the correct answer to the question: 'On which branch of mathematics is digital technology based?'

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Information Skills of Finnish Basic and Secondary Education Students: The Role of Age, Gender, Education Level, Self-efficacy and Technology Usage

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ABSTRACT

The information skills and technology use of 3,159 Finnish 12–22-year-old students were examined in this study. Data were collected using the combination of a usage habit questionnaire and a performance-based test that measured their skills when choosing a medium to seek information, defining search queries, and selecting and evaluating search results. On average, these students' information skills were found to be insufficient. Particularly, students failed in creating search phrases, and they tended to concentrate on content relevance at the expense of source reliability. Versatility of technology use was found to be the most prominent predictor of students' information skills. Education level also had an increasing effect on information skills, whereas age alone, within separate education levels, did not have the same effect. Self-efficacy was found to be associated only with male students' information skills. Gender had no direct effect on information skills; rather it was identified as a moderator for the ongoing relationship between information skills and technology use.

Keywords
information skills, technology usage, self-efficacy, Internet, Finnish students

INTRODUCTION

Applying Facer and Furlong (2010), the expansion of digital technologies into social, economic, and personal lives in the developed countries has made information a key factor for success. A lack of information skills can lead to severe inequality between differently skilled people. Further, these skills increasingly determine one's position in the labour market and civic and social life as well (van Deursen & van Dijk, 2016). Information skills are also crucial for lifelong learning, and have been found to have a positive impact on students' academic achievement, particularly for students with a low socioeconomic background or with low academic performance (Pagani, Argentin, Gui & Stanca, 2015).

The Nordic countries are seen as welfare states with stable economies and a clear intention to reduce inequality by means of a common education (see Tømte & Hatlevik, 2011). In spite of several similarities, the Nordic countries have not been performing equally on international comparative assessments, such as PISA. Finnish students have time after time ranked highest among Nordic countries in reading, mathematics, and scientific literacy. An interesting feature of Finnish PISA success is that Finland was the only country where girls were more likely to be top performers than boys in all literacy areas. However, the PISA results are not only positive for Finland, but negative too, as the successful trend has been decreasing in all literacy areas, and results indicate the lack of information technology utilisation in learning. (OECD, 2016; 2015.)

Based on the PISA 2012 results (OECD, 2015), at least 99% of all students in the Nordic countries had access to the Internet at home. In Finland, based on the statistics from 2017 (OSF, 2017), 100% of 16–24 year olds have used the Internet, and 95% reported they usually access it several hours each day. Furthermore, the PISA 2012 results indicated that in Finland, like other Nordic countries, most students have used computers since they were six years old or even younger (OECD, 2015). Based on these indicators, it can be argued that there is no divide in Finland based on whether students in basic or secondary education have access to the Internet. Instead, in highly technologised societies, differences are focused in skills and usage, and in potential benefits as well (see e.g., van Deursen & Helsper, 2015). Therefore, in Finland and other Nordic countries, attention should be paid to the ways that young people actually use these digital technologies.

Given that venue, the PISA results for Finland have indicated that the reality in most of the examined schools lags behind the promise of technology. Young people in the Nordic countries are experienced in using digital technology outside school, but especially in Finnish schools, the use of technology remains remarkably low in the schools despite the availability of the equipment. In Finland, 35% of students reported using the Internet for schoolwork at school, and only 28% reported using the Internet for doing homework at home. These figures are remarkably low compared to other Nordic countries, except for Iceland, where the situation is very similar to that in Finland. (OECD, 2015.) Therefore, there seems to be an increased gap between Finnish schools and their outside-of-school reality. How this reality affects digital literacy is not comparable between the Nordic countries, however, as only Norway, Denmark, and Sweden participated in computer-based reading assessments in PISA 2012. The results of these three countries proved to be mixed. In Sweden, students performed better than would be expected based on their performance on pencil-and-paper assessment, whereas in Norway and Denmark, students' performed lower than expectations. (OECD, 2015.)

The current study aims to examine the information skills of Finnish students from basic and secondary education, and to acquire a clearer understanding of those students' technology usage, most of which takes place outside school settings. The curricula in both basic and secondary education have been recently updated in Finland, and both digital and information skills are now more appropriately presented in the learning objectives. Nonetheless, a better understanding of the relationships between information skills and the technology usage of young Finns provides valuable information which could also provide novel paths for formal education in all Nordic countries to strengthen the equal distribution of these key competencies.

INFORMATION SKILLS

In addition to measuring traditional literacy skills, PISA 2012 (OECD, 2015) examined how well fifteen-year-olds in thirty-one OECD countries were able to navigate, read, and understand online texts. The study used a simulation environment to produce a controlled setting wherein students' browsing behaviours could be closely observed. According to the results, top performers could navigate efficiently and autonomously. They also evaluated information from several sources, assessed the credibility and utility of what they read, and used criteria they had personally generated. Low performers had difficulty using the navigation tools and features, and also locating information that was not readily and prominently placed.

The above findings emphasise the inseparable connection between information and Internet skills. In fact, based on Gui (2009), most of the research on Internet skills has either implicitly or explicitly focused on information skills. The same is true the other way around. The definition of information skills as a dimension of broader Internet skills has been proposed in earlier research. According to van Deursen and van Dijk (2016), Internet skills are multi-dimensional, and can be divided into operational skills (technical competence); formal skills (navigation and browsing); information skills (searching, selecting, and evaluating digital information); communication skills (using technology for communication and networking); content creation skills (i.e., writing blogs or tweets, editing images); and strategic Internet skills (using technologies to set goals and achieve them. Of these, operational and formal skills are medium-related skills, while information, communication, content creation and strategic skills are content-related skills. Medium-related skills are the technical aspects needed to use the Internet or other digital environments and content-related skills are indeed enabled by these technical skills. (van Deursen & van Dijk, 2016.)

Van Deursen, Görzig, van Delzen, Perik, and Stegeman (2014) found that Dutch students possessed sufficient medium-related skills (including both operational and formal skills), but had insufficient levels of content-related skills (information and strategic skills). Earlier, van Deursen and van Diepen (2013) observed the skills of Dutch students and found that education was the main contributor to success in information skills assignments: The higher the level of education, the better the average rate of fully completed assignments. The frequency of Internet use or Internet experience was not significant for the successful completion of such assignments. Gender also had no impact on students' information skills. In general, the study found a lot to improve upon, particularly the students' abilities to define search queries and evaluate information – namely, to find the source of the information, maintain precise focus, and take the appropriate steps to reach the end goal.

Similarly, Finnish adolescents' information skills were also found to be deficient (e.g., Kiili, Leu, Sandvik, Marttunen & Leppänen, 2015). For example, Kiili (2012) found that students had considerable difficulty locating relevant information on the Internet. Students more frequently evaluated relevance rather than the credibility of the information. Students struggled with formulating adequate search queries, understanding how search engines work, analysing their search results, and regulating their own search activities. In a more recent study, Kiili et al. (2015) examined the online reading skills of Finnish basic education sixth graders, and found critical evaluation especially challenging for students, particularly if tasks required recognising biased information.

TECHNOLOGY USAGE

Technology usage is usually described in terms of frequency and variety of use (e.g., Brandtzæg, 2010). The major problem with such research has been diversity of use and the constant change that makes concepts scatter. However, Helsper's (2012) corresponding field model offers a theory-grounded and general categorisation for technology usage that is based on benefits that are actualised through usage. The benefits can be categorised as: Economic (an increase in property, education, employment, or income), cultural (belonging or identity), social (informal and formal networks, or e-government), and personal (self-actualisation, leisure, or health). These outcomes of digital use can also be seen as typical domains of technology usage. In Helsper's (2012) classification, economic use consists of commercial, financial, information and learning activities; cultural use includes creative and productive activities, for example, those related to identity creation or belonging to a group of like-minded people; social use consists of communication, interaction, participation, and engagement activities in informal, formal and political networks; and personal use are those activities related to entertainment and leisure, self-actualisation, and health. Still, online activities are not limited to a particular usage domain. For example, even if entertainment-related activities are typically part of the personal usage domain, they are often used also to connect to others which makes them part of the social usage domain, too. Multiplayer games are an example of this kind of activity that can load into several usage domains. (van Deursen, Helsper, Eynon & van Dijk, 2017.)

Previous research has found that in developed countries, the digital divide has shifted from differences in access (to devices and the Internet) to differences in usage and skills (e.g., Hargittai, 2010), and even further to differences in the returns gained from Internet use, in other words, differences in benefits gained from digital technology use for offline outcomes (van Deursen & Helsper, 2015). Different kinds of usage are related to differences in Internet skills (Hargittai, 2010). Studies have demonstrated that young people use digital technologies more frequently at home than in educational settings (e.g., OECD, 2015). Students use digital technologies at home mainly for recreational purposes rather than for school-related activities (Scherer, Rohatgi & Hatlevik, 2017). Young people's engagement with technologies is often rather restricted when compared to the common beliefs about young people's activities on the Internet (Hargittai, 2010).

In a previous study, Hargittai (2010) found that students in the U.S. were differentiated by the contexts of Internet usage; user experience explained the observed variation in Internet skills. Those with higher level of skills engaged in more activities online. Diverse types of information-seeking activities online were associated with higher Internet skills. Based on her results, socioeconomic status is an important predictor of usage and skills, as those with higher levels of parental education or those being male use technologies in more informed ways and for a larger number of activities and thus gain more benefits from that use.

The present study examines the information skills and digital technology use of Finnish basic and secondary education students. It analyses the levels of both skills and usage and focuses on how they differentiate by age, gender, and education level. Based on previous research, education, age, and gender were expected to be the most substantial predictors for differences in both information skills (e.g., van Deursen & van Diepen, 2013; Gui, 2009) and digital technology usage (van Deursen & van Dijk, 2013). In addition, the current study examines the role of self-efficacy (the degree to which students believe they can master ICT-related tasks) for information skills, as the self-efficacy has noticed to play an important role in students' digital literacy skills in overall Nordic research literacy (e.g., Scherer et al., 2017).

This study poses the following research questions:

1. What are the information skills and related self-efficacy levels of Finnish students? And are gender, age, and education level related to these students' information skills?
2. What are the levels of Finnish students' technology usage in different usage domains in terms of quantity and versatility? And are gender, age, and education level related to these students' technology use?
3. How does the digital technology usage by Finnish students relate to their overall information skills?

METHODOLOGY

Participants

The data were collected in Finland during 2014 and 2015 from forty-one lower secondary (grades 7–9 of 9) and upper secondary level schools (grades 1–3 of 3). Altogether, 3,159 students were tested: 52% of the students were male, and 48% were female. The students ranged in age from 12 through 22. The mean age was 15.9. In the Finnish education system, basic education covers ISCED levels 1–2 (1 = primary and 2 = lower secondary education) and secondary education level covers ISCED level 3, that is, upper secondary education, which is divided into general and vocational education. 40% of these students came from the basic education level (lower secondary schools), and 60% came from upper secondary level education. Of those upper secondary level students who participated in this study, 54% came from general upper secondary schools, while 46% came from vocational institutions.

Measurements

The data were collected using an online usage habit questionnaire and the ICT skill test. The questionnaire collected background information (gender, age, and educational level) and information about how frequently the examinees used digital devices (computers, laptops, tablets, and mobile phones (with scoring ranging from 0 = never, 1 = sometimes, 2 = weekly, 3 = daily to 4 = several hours per day) and how frequently (on the same scale) they used digital technologies for different purposes which were later categorised to usage domains based on Helsper's (2012) classification: Economic, cultural, social, and personal use (see categorisation and item descriptives in Appendix 1).

The original ICT skill test (developed in 2013) was utilised in this study. It consists of forty-two tasks, grouped into seventeen fields related to ICT skills (Kaarakainen, Kivinen & Vainio, 2018). In the current paper, only participants' performance on the information skills tasks was analysed. The information skills item on the ICT skill test contained five tasks, described below (see the representation of the implementation in Figure 1).

Choosing a medium:

- *Task I:* The students were asked, in a multiple-choice question, where they would most probably find the Finnish Defence Forces wartime photograph archives (options were: a. Google images, b. Wikimedia Commons, or c. The Finnish Defence Forces photo library ✓). Scores for this task ranged from 0 to 1.
- *Task II:* The students were asked, in a multiple-choice question, where they would find certain scientific publications as the source of a newspaper article (options: a. databases of the journals that publish research results ✓, b. web page of the newspaper, or c. Google or another search engine). Scores for this task ranged from 0 to 1.
- *Task III:* The students were asked, in a multiple-choice question, how to find a certain car enthusiast's discussion forum in a situation where the URL of the discussion forum was not known: (a. Autotalli.com (popular Finnish car themed website), b. Google ✓, or c. the Yellow Pages). Scores for this task ranged from 0 to 1.

Defining a search query:

- *Task IV:* The task required filling in (an open-ended question) a search query to search for information produced for children about the dwarf planet Pluto on the European Space Agency's website (esa.int) in a way that the results would not contain any websites about the Disney character, Pluto. The search operators were given an instruction below the task. It was possible to get a total of three points: One from correct use of the site-operator ("site:"); one from correct use of the NOT-operator ("-"); and one from the right keywords (e.g., "children" and "Pluto"). The right answer was, for example, "site: esa.int Pluto children -Disney" or "Pluto planet for children -dog site:esa.int". Different terms and phrasings in both Finnish and English were accepted as correct keywords. Some inaccuracies in spelling were also allowed.

Selecting and evaluating information:

- *Task V:* The students were asked to choose the best search results for a specific information seeking assignment (information about a children's ear infection, especially symptoms that required a visit to the doctor) based on both the relevance of the content and the reliability of the source. Ten different search results were provided as options. Some led to unreliable texts sources like blogs or Internet discussions, and some dealt with irrelevant content. Two search results on children's ear infections led to official sites (i.e., correct options), namely, the patient guidance site for the Hospital District of Helsinki and Uusimaa (HUS) and the national Current Care Guidelines site. The graphic expression of these search results resembled the representation of typical search engines (e.g., Google). The task was a multi-select type question with two correct answers: thus, scores of this task ranged from 0 to 2.

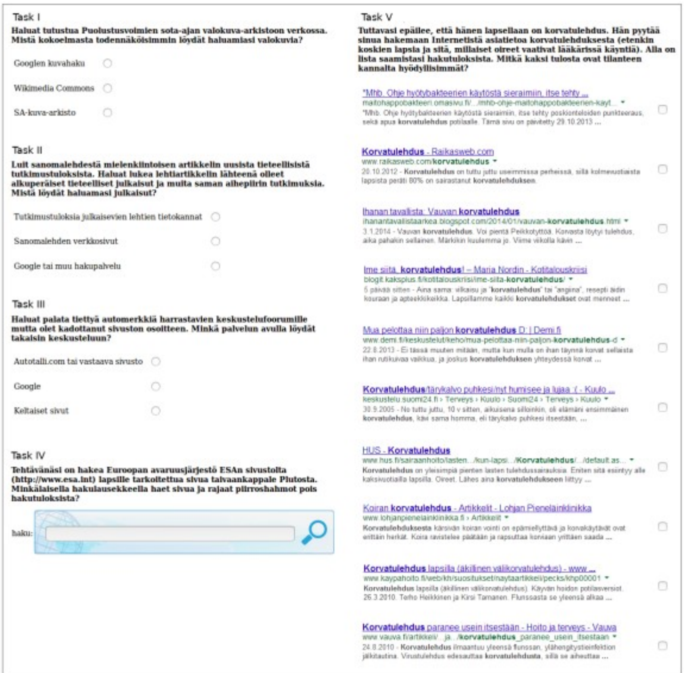

Figure 1. The implementation of the tasks.

Apart from the search query task, the information skills items were automatically evaluated. Answers for the search query task were then rated by three researchers to increase the reliability of those ratings. In a separate questionnaire, test-takers were asked to evaluate their own skills in the tested areas as 0 = does not have the skills, 1 = possesses basic skills, 2 = possesses advanced skills in the particular domain. Students' self-evaluation scores (self-efficacy) could thus be combined with the actual performance scores.

Data Analysis

The reliability of the usage habit questionnaire was assessed using Cronbach's alpha: the value being .87. The validity of information skills tasks were assessed using item difficulty, an item's ability to discriminate between high achievers and low achievers, and measuring the strength of the association between tasks. Item difficulty ranged between .23 and .77 (see Table 1), indicating that none of the tasks was either too difficult (<.2) or too easy (>.8). The item discrimination index varied between .39 and .77, exceeding the threshold of .3, meaning that items discriminated properly between high and low performers. The corrected item-total correlation values ranged between .11 and .49, indicating that task 3 was below the threshold value of .15. However, taking into account all the item level indicators, it was justifiable to include all tasks in the further analyses.

Table 1 Results of the item analysis

Task	Item Difficulty Index	Item Discrimination Index	Corrected Item-total Correlation
I	.59	.39	.40
II	.34	.50	.17
III	.77	.39	.11
IV	.23	.67	.49
V	.50	.77	.24

The relationships between information skills and age, educational level, self-efficacy, the four usage domains, the use of devices, and the versatility of use were analysed via a multiple linear regression analysis, which allows one to examine the role of multiple independent variables for any variance of a dependent variable. To assess the role of gender as a moderator in these relationships, separate analyses were performed for female and male students. All the variables in the regression were standardised on the same scale allowing for a comparison of the magnitude of the coefficients. The autocorrelation influence of regression models were assessed using the Durbin-Watson test and were favourable for both models.

RESULTS

Finnish Students' Information Skills

The mean scores for the information skills by gender are shown in Table 2 and by education level in Table 3. The students succeeded best in search channel tasks I and III. However, search channel task II turned out to be challenging for the majority of students. In the first two search channel tasks, the students should have understood that the needed information could not be attained using a search engine, but instead had to come from network archives and databases. For the last search channel task, the search engine was the right way to find a discussion forum, and the majority of the students did succeed in finding that right answer.

Defining a search query was the hardest task for the participants. Overall, the search phrases created by the participants were too simple (53%) and did not cover the entire assignment, for example "ESA Pluto", "Pluto for children" or just "Pluto". Nearly a quarter of the students used search operators erroneously or defectively. For example, when the search required the use of the site-operator, the students used a wrong operator instead, such as "link:esa.int pluto kids" or did not use the operator at all (e.g., "pluto for kids esa.int"). Surprisingly many (12%) tried to create a web address instead of a search phrase, and 6% wrote requests or questions to the search engine, such as "What does ESA say about pluto?"

In task V, about 60% of the students identified the first correct search result (the patient guidance site by HUS). However, only about a third found the other correct option (Current Care Guidelines). One-third of the students selected search results that concerned ear infections, but where the actual source was unreliable (a blog about different kinds of health and alternative medicine-related topics). Further, more than 5% of the students simply guessed that the correct choice would be another blog post (a Finnish housewife who wrote about her child's ear infections). Instead, the students only rarely picked options with irrelevant topics (ear infections in dogs and beneficial bacteria) or options from the discussion forum posts, which they did successfully identify as unreliable sources.

Male students performed significantly better in search channel tasks I and III than the female students. In contrast, in search channel task II, female students slightly outperformed the male students. The female students succeeded significantly better than the male students in evaluating search results, whereas, for the search phrase task, both genders failed equally. The difference in information skill item total scores between the genders was not statistically significant. Secondary education students performed significantly better in all the information skills tasks than the basic education students.

Table 2 Performance on information skills tasks by gender

Tasks	All Together M (SD)	Female Students M (SD)	Male Students M (SD)	t-value	p-value
Search Channel, I	.59 (.35)	.56 (.34)	.62 (.35)	−5.355	.000***
Search Channel, II	.34 (.47)	.36 (.48)	.32 (.47)	2.382	.017*
Search Channel, III	.77 (.38)	.75 (.40)	.80 (.35)	−4.037	.000***
Search Phrase	.23 (.20)	.23 (.20)	.23 (.21)	−.152	.880
Evaluating Search Results	.50 (.32)	.55 (.31)	.46 (.33)	7.848	.000***
Total Scores	2.43 (.96)	2.45 (.96)	2.43 (.97)	.264	.792

*** $p < .001$, * $p < .05$

Table 3 Performance on information skills tasks by education level

Tasks	All Together M (SD)	Basic Education Students M (SD)	Secondary Education students M (SD)	t-value	p-value
Search Channel, I	.59 (.35)	.55 (.34)	.62 (.35)	−5.360	.000***
Search Channel, II	.34 (.47)	.30 (.46)	.37 (.48)	−3.863	.000***
Search Channel, III	.77 (.38)	.70 (.41)	.82 (.34)	−8.584	.000***
Search Phrase	.23 (.20)	.16 (.13)	.28 (.23)	−19.828	.000***
Evaluating Search Results	.50 (.32)	.42 (.30)	.55 (.32)	−11.243	.000***
Total Scores	2.43 (.96)	2.13 (.94)	2.64 (.99)	−14.576	.000***

*** $p < .001$

Students' own evaluations of their information skills (self-efficacy) were found to be notably better than their actual performance. As much as 70% of students reported having advanced information skills, and 29% rated themselves as having at least basic information skills. Only 1% of students reported that they did not have the skills in question. Male students had significantly higher self-efficacy (M 1.72, SD .47) than female students (M 1.67, SD .48) ($t = -2.868$, $p = .004$). Differences in self-efficacy between education levels were also significant ($t = -2.957$, $p = .003$), as the students from the basic education level scored on average, 1.66 with a standard deviation of .49, and students from secondary education in turn scored 1.72 with a standard deviation of .46.

Finnish Students' Technology Use

Table 4 represents the mean scores for technology usage by gender and Table 5 by education level. Students were noted as scoring the highest on the social use domain; the personal use domain was the second most common, and economic use ranked third. Students used digital technologies least for purposes categorised as cultural use. Male students were more active users of digital devices than female students. Specifically, they were more active in the economic use and personal use domains and versatility of use. Female students were noticed to be more active in cultural use. Education level was found to have a significant impact on use activity, in terms of use of devices, activity in usage domains and versatility of use. The transition from basic to secondary education especially increased economic use and versatility of use among the students.

Table 4 Technology usage by gender

Sub-items	All Together M (SD)	Female Students M (SD)	Male Students M (SD)	t-value	p-value
Economic Use	1.11 (.45)	1.07 (.42)	1.14 (.49)	–4.142	.000***
Cultural Use	.93 (.45)	.98 (.40)	.89 (.49)	5.178	.000***
Social Use	1.73 (.51)	1.73 (.44)	1.75 (.57)	–.871	.388
Personal Use	1.37 (.66)	1.16 (.54)	1.57 (.69)	–18.295	.000***
Versatility of Usage	21.48 (5.54)	21.01 (4.83)	21.92 (6.09)	–4.706	.000***
Use of Devices	2.17 (.56)	2.10 (.49)	2.17 (.56)	–3.810	.000***

*** $p < .001$

Table 5 Technology usage by education level

Sub-items	All Together M (SD)	Basic Education Students M (SD)	Secondary Education students M (SD)	t-value	p-value
Economic Use	1.11 (.45)	.88 (.40)	1.26 (.43)	–25.720	.000***
Cultural Use	.93 (.45)	.88 (.46)	.97 (.44)	–5.149	.000***
Social Use	1.73 (.51)	1.62 (.51)	1.81 (.49)	–10.157	.000***
Personal Use	1.37 (.66)	1.29 (.68)	1.42 (.63)	–5.755	.000***
Versatility of Usage	21.48 (5.54)	19.04 (5.37)	23.09 (5.04)	–21.297	.000***
Use of Devices	2.17 (.56)	2.01 (.53)	2.22 (.51)	–11.326	.000***

*** $p < .001$

Figure 2 represents a histogram of usage versatility (online activities that test-takers rated as having used at least sometimes) by gender. It shows that at the lowest, students reported having only four, and at the most thirty-four, online activities, and in both the lower and higher end of the distribution, male students were the majority. On average, students rated their use to be at least "sometimes" for about twenty-two different online activities (i.e., versatility of usage) and in average six online activities they used "daily" or for "several hours a day". The most common online activities were instant messaging, information searching, video-sharing, photo-sharing and social networking services, and downloading/listening to music online. Students' used technology the least for the following: Programming, computer graphics, audio or video editing software, e-government and online banking services. These were used only by a small group of active hobbyists, and in the case of e-government and online banking services, the oldest students.

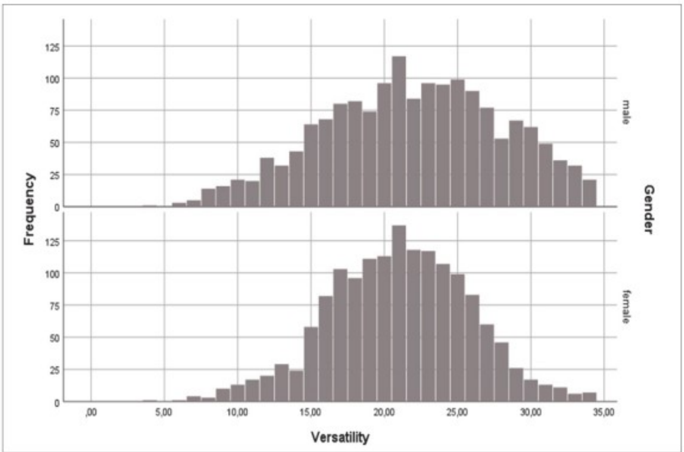

Figure 2. The versatility of online activities by gender.

A multiple linear regression was conducted to examine the relationship between information skills, students' background variables, usage variables, and self-efficacy more closely. Because female and male students scored equally on information skills item total scores, but indicated remarkable differences in usage, these regression analyses were performed separately for both genders. Table 6 represents both regression models. A significant regression equation for female students was found (*F(9, 1,442)* = 18,970, $p < .001$), with an R^2 of .106. The best predictors of information skills among female students were the versatility of technology use (β = .201) and education level (β = .125), which had a significant and increasing effect on female students' information skills. In addition, personal use was a significant negative predictor (β = –.070) for female students' information skills.

For male students, the analogous significant regression equation was (*F*(9, 1,516)= 22.046, $p < .001$), with an R^2 of .116. For male students, the best predictors of information skills were versatility of technology use (β = .195), education level (β = .159), social use (β = .130), self-efficacy (β = .084), and use of digital devices (β = .062). Personal use (β = –.183) and cultural use (β = –.244) were found to decrease male students' information skills.

The economic use alone correlated (r = .245) with information skills, but for the education level in the models, its importance remained insignificant, as the economic use increased remarkably when student education level increased. For male students, the positive effect of social use remained, despite the fact that education level was taken into account. The main online activity that distinguished male and female students within the social use domain was multiplayer video games, with 99% of the weekly (or more) players being male students.

Table 6 The multiple linear regression models of information skills' predictors for female and male students

Independent Variables	Model 1 Female Students			Model 2 Male Students		
	B	SE	β	B	SE	β
Age	.123	.107	.044	–.035	.095	–.013
Education level	.100	.030	.125**	.132	.030	.159***
Economic Use	.088	.085	.047	.109	.072	.065
Cultural Use	.006	.090	.003	–.244	.066	–.149***
Social Use	.009	.083	.005	.183	.056	.130**
Personal Use	–.102	.045	–.070*	–.183	.039	–.139***
Versatility of Usage	.282	.067	.201***	.219	.053	.195***
Use of Devices	–.072	.046	–.045	.090	.043	.062*
Self-efficacy	.041	.021	.049	.072	.022	.084**
R	.325			.340		
R^2	.106			.116		
F	18.970			22.046		
Durbin-Watson	2.046			1.995		

B = the unstandardised beta, SE = the standard error for the unstandardised beta, β = the standardised beta,* $p < .05$, ** $p < .01$, *** $p < .001$

DISCUSSION

Concerning the research question on students' information skills, in this current study, those skills were found to be insufficient, especially for creating a search phrase; only 1% formed a comprehensive search phrase with correct syntax, and fewer than 15% achieved half of the points available. Students also struggled in the task, which required evaluating search results. One-third of the students settled with the first search result available, and many concentrated on content relevance at the expense of source reliability. There were no differences between genders in the total scores for information skills, but male students did dominate in tasks, which required locating information resources. Female students in turn possessed the ability to evaluate search results. In the search query task, both genders failed equally. Overall, there is room for improvement of students' information skills.

Self-efficacy was found to have a positive effect only on male students' skills. Male students were also found to have higher information skills -related self-efficacy than female students. Previously, it has been indicated in general, but particularly in Finland, that male students have better overall ICT self-efficacy than females (Tømte & Hatlevik, 2011). Furthermore, self-efficacy has been noted to have a significant effect on students' performance on assignments' requiring digital skills (i.e. Scherer et al., 2017). Hargittai and Shafer (2006) have argued that the lower self-assessments of females regarding Internet skills may have significant effects on the extent and types of online activities in which they engage.

When it comes to the research question about the usage of digital technologies, based on the results Finnish students were found to be most active in social and personal use domains, and least active in cultural use. The level of education was found to increase the students' economic use and versatility of use in particular. The most limited users of technologies were mainly male students from the basic education level. Even so, the most versatile users of the current data set were still observed to be males.

Based on current results, it seems that the versatility of students' online activities provides them with the best prerequisites for acquiring and practicing the development of information skills. For male students, potential learning experiences are also generated as a part of their online activities within the social use domain. The key difference between the genders in the case of the social use was the male students' active engagement with multiplayer video games. Steinkuehler and King (2009) have stated that multiplayer video games indeed can function for boys as an attraction to acquire important digital literacy practices. Steinkuehler (2007) argued that these kinds of games are literacy activities, and at their best, they can serve as interest-driven arenas for knowledge construction (Steinkuehler & Squire, 2014).

As information skills are inextricably linked to broader digital and Internet skills, the improvement of information skills necessitates that formal education focuses on students' overall digital abilities. Based on van Deursen and van Dijk (2013), efforts to reduce the disparities in information skills or Internet skills in general, consideration of individual usage habits plays a significant role in acquiring more of these skills. These researchers also highlighted that education, age, and gender are the most important predictors for any differences in digital technology usage. Based on the results of multiple regression analyses in this study, versatility of usage and education level were the most prominent predictors of information skills for both genders. Age alone, within the specific educational level, did not prove to be a meaningful factor for this age group.

Nevertheless, the use of digital technologies and the Internet at home or other informal settings does not ensure adequate skills for every student. Thus, formal education has a crucial role to play for supporting all students to develop these skills. Van Dijk and van Deursen (2014) specified that unlike operational or formal skills, which are mainly learned via practice and often learned outside of formal education, information skills are completely different and are not achieved sufficiently enough at home by just trial and error. Formal education is the key to moderating the disparities present among differently skilled individuals. Pagani et al. (2015) argued that focusing on increasing students' information skills and their general digital skills can indeed play an important role in reducing educational inequality.

As has been argued, information skills are inseparably linked to other digital skills. In the PISA 2012 report (OECD, 2015), information skills are said to be a crucial factor for digital literacy and further still, also vital for participation in the economic, social, and cultural life found in the swirl of today's complex digital landscape. Van Dijk and van Deursen (2014) pointed out that a major problem has been that these skills are too often delivered in schools by means of traditional media and printed learning materials. Information provided on the Internet has its own unique nature, and it differs from traditional media. It is infinite, and therefore, it places more pressure on students' content-related skills. In formal education, students should be encouraged to train their information skills in a rich and varied literacy environment in the context of both traditional and digital media. Diversifying students' online activities at school can further open the interest-based environment necessary for students to accumulate these key competencies for academic success and for life later on, when they become adults in an ever-increasingly technically-oriented society.

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APPENDIX

Appendix 1. Items on the usage habit questionnaire, the descriptive statistics, and categorisations for usage domains.

Item	M (SD)	Economic use	Cultural use	Social use	Personal use
'I use digital technology (computers / laptops / tablets / smartphones) for: (0 = never, 1 = sometimes, 2 = weekly, 3 = daily, 4 = several hours a day)'					
Social networking services	2.36 (1.01)			x	
Video-sharing services	2.53 (.88)		x	x	
Photo-sharing services	1.95 (1.37)		x	x	
Web blogging	.69 (.91)		x	x	
Internet discussion forums	.64 (.81)		x	x	
E-government services	.44 (.60)	x			
Online banking	.50 (.79)	x			
Online shopping	1.02 (.72)	x			
Online newspapers	1.72 (1.08)	x			
Newsgroups	.57 (.89)	x			
Weather services	1.37 (.98)	x			
E-mailing	1.95 (.92)	x		x	
Instant messaging	3.17 (.95)			x	
Voice/video chatting	1.05 (1.27)			x	
Video/computer games (in single-player mode)	1.05 (1.30)				x
Video/computer games (in multi-player mode)	1.04 (1.41)			x	x
Casual gaming	1.08 (1.08)				x
Search engines/information searching	2.72 (.73)	x			
Web-mapping/route planning services	1.24 (.74)	x			
Vertical directories	.65 (.74)	x			
Wikis	1.49 (.80)	x			
Online dictionaries	1.30 (.86)	x			
Watching TV-series online	1.39 (.91)				x
Downloading/listening to music online	2.18 (1.38)				x
Downloading/watching movies online	1.49 (1.17)				x
Word processing	1.16 (.91)	x			
Spreadsheets	.62 (.75)	x			
Presentations	.77 (.74)	x			
Image manipulation/editing	.74 (.84)		x		
Audio editing	.26 (.61)		x		
Video editing	.40 (.72)		x		
Computer graphics	.25 (.61)		x		
Computer programming	.19 (.55)	x			
e-learning environments	.59 (.92)	x			

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Differences between the genders in ICT skills for Finnish upper comprehensive school students: Does gender matter?

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Abstract

This study examined the ICT skills of Finnish upper comprehensive school students. The data has been collected from 65 municipalities around Finland for 5455 ninth graders (mean age 15.24). ICT skills were measured using a digital, performance-based ICT skill test. The test was based on the revised Finnish national core curriculum for basic education. Based on the results, there was a small, but statistically, significant difference between the genders in the total scores on the ICT skill test. More consequential differences between the genders were found in the item level analysis. As explicit item level analysis indicated, boys tended to get better scores from more technical-oriented items, while girls got better scores from school work-oriented and social interaction-related items. The results emphasize that gender differences in ICT skills are more item specific than general. More importantly, the variation between individuals in ICT skill items was extensive and in all likelihood more influential than the gender difference as such.

Keywords: *ICT skills, Genders differences, Upper comprehensive school students*

1 Introduction

Ongoing digitalisation is changing every aspect of society. The growing amount of (digital) data, digital infrastructures, online artefacts and transaction systems, among numerous other things, are changing the way that people study, work, communicate, and live their everyday lives. Today's Western societies are described as digital societies, where new information and communication technologies shape the landscape of everyday living. This digital citizenship demands new kinds of literacies and digital competencies for one to be able to operate and participate in society (Gallardo-Echenique et al., 2015).

There is continuing debate around what the essential skills in digital societies are. The DIGCOMP framework project uses the concept of digital competence and categorises these crucial competences for information, communication, content-creation, safety and problem-solving (Ferrari, 2013). In turn Binkley et al. (2012) use the 21st century skills concept to describe the ways of thinking, working, and living in a digitalised world. Fraillon et al. (2013) apply the construct of computer and information literacy that relates to an individual's ability to use technologies to investigate, create, and communicate and participate effectively at home or school and in the workplace or society.

The purpose of this study is to examine the differences in information and communication technology (ICT) skills between the genders in the context of the Finnish national core curriculum for basic education. The intent of the core curriculum is to provide a common ground for the local curricula and promote equality and equity in education. It contains the guidelines for providing education as well as the objectives and key content of instruction. In the core curriculum, ICT skills are one of the seven *transversal competences* which are integrated into all subjects. ICT skills are considered to be an essential aspect of civic competencies and are seen both as a goal and a tool for learning. In practice, the goal is to offer every student the following skills: Understanding of the basic operations and concepts of ICT, knowledge to use ICT in a responsible, safe, and ergonomic manner; the skills to use ICT as a tool for information management and creative work; and the abilities to use ICT in interaction and networking. Overall, the aim is to offer the experiences in using different applications to understand their meanings for everyday life, communication and public influence. (FNBE, 2016.) In this study, we are particularly interested in the learning goals for actual ICT skills, instead of studying ICT as a tool for learning.

The research questions are: 1) Are there differences between the genders in ICT skills between upper comprehensive school students? 2) What kinds of differences exist between the genders?

2 ICT skills

2.1 Concepts

Various concepts are used to define the skills required for ICT use. Concurrently with digitalisation, terms like IT, ICT, and computer literacy have become dominant. (van Laar et al., 2017; Bawden, 2008.) In most cases, these concepts consist of a domain part (computer, ICT, Internet, etc.) and a knowledge perspective (competence, literacy, skill, etc.) (Hatlevik et al., 2015). In their systematic literature review on the different perceptions of 21st century skills, van Laar et al. (2017) made a distinction between 21st century skills and digital skills. Based on their results, 21st century skills are broader than digital skills and are not necessarily underpinned by ICT, while digital skills involve that connection. Based on the 75 reviewed articles, the authors created a framework of seven core skills and five contextual skills. The seven core skills are: Technical usage, information management, communication, collaboration, creativity, critical-thinking, and problem-solving. The five contextual skills are: Ethical awareness, cultural awareness, flexibility, self-direction, and lifelong learning.

In the definition offered by van Laar et al. (2017), technical usage is seen as the skill to use devices and applications. Information management skills are used to search and use information, including knowing what sources of information to use. Communication skills are used to transmit information to others. Collaboration skills are used to create social networks and be able to work as a team using ICT. Creativity skills are used to create new ideas or redefine old ones. Critical thinking skills are used to evaluate gathered information and communicate with others. Problem-solving skills are used both for finding information to solve problems and using ICT to solve those problems.

In spite of the diversity in the concepts, ICT skills or competences are considered essential skills for social interaction, civic participation, information retrieval and processing, academic performance, and professional success (see e.g. Hoffman & Schechter, 2016; Pagani et al., 2016; Zhong, 2011). Consequently, ICT skills should be considered necessary educational outcomes for every student in digitalised societies, and thus, a valid assessment of ICT skills is crucial (Aesaert & van Braak, 2015). In this study, the term ICT skills refers to the digital skills or competencies in line with the definition of the seven core skills offered by van Laar et al. (2017) and the learning goals for ICT skills found in the Finnish national core curriculum (FNBE, 2016).

2.2 Measuring ICT skills

In her review, Litt (2013) classified the ICT skill assessment methods as: 1) survey and self-reported measures; 2) performance/observation measures; and 3) combined and unique assessments. Surveys and self-reports seem to be the dominant methods for ICT skill assessment. In these assessments, participants respond to a question or a set of questions about their own competence level or evaluate their ability to perform specific tasks on the Internet (e.g. Heerwegh et al., 2016; Livingstone & Helsper, 2010). Qualitative studies prefer observation-based measures or interviews, which incorporate ethnographic practices. These types of studies focus on, for example, observing a person's actions during information search tasks (see e.g. Hargittai, 2002). Interviews in their turn typically utilise open-ended questions like 'What are you strong in?' (Litt, 2013). Some performance-based studies have conducted task-based assessments and virtual environments to mirror the actual environment where the ICT skills are being used (e.g. Claro et al., 2012; van Deursen & van Dijk, 2009).

In their review of assessment instruments Siddiq et al. (2016) concluded that the majority of the utilised assessment instruments are based on self-reporting. Most were online tests with multiple-choice questions. Some also included questions in a dynamic format that required participants to interact with the tasks. A few had a dynamic task design that required interaction with the test environment. Most of the tests were evaluated using quantitative methodology. Siddiq et al. (2016) summarises by saying that the majority of these tests assess information search, retrieval, or evaluation, and technical skills; however, aspects like problem-solving with ICT, digital communication, and online collaboration are not covered to satisfaction.

It is well known that measurements based on participants' own evaluations face validity problems, as people tend to overrate or underrate their own levels of competence (e.g. van Deursen et al., 2016; Aesaert & van Braak, 2015; Litt, 2013). There is, as Litt (2013) and van Deursen et al. (2016) emphasise, an urgent need for more accurate, nuanced, and reliable assessment instruments for greater generalisable and diverse samples that can capture the phenomenon in its entirety.

2.3 Gender and ICT Skills

In their longitudinal cross-sectional study of representative samples from the Dutch population on Internet skills, van Deursen and van Dijk (2015) noticed men scoring higher than women on all skill domains: Operational skills (e.g., saving files, downloading programs, using the refresh button); formal skills (e.g., being familiar with web site structure); information skills (e.g., finding information, using search booleans); and strategic skills (e.g., gaining financial benefits, and making decisions based on retrieved information). To the contrary, among students, previous research results on gender differences in ICT skills have been quite diverse.

In their study, Aesaert and von Braak (2015) noticed that among primary schoolers, girls perform better in tasks that relate to communication-oriented activities and deliver digital information with understandable content to the receiver. In the study by Ritzhaupt et al. (2013), middle school girls were found to be outperforming boys in all technology literacy domains. The five examined domains were: Technology operations and concepts (e.g., creating new files, locating and opening files, selecting the best device to complete a given task); constructing and demonstrating knowledge (e.g., selecting the correct printer, setting page margins within a word processing document, editing images); communication and collaboration (e.g., practical keyboard skills, using e-mail, and creating new slides within presentation software); independent learning (e.g., using print preview, deleting data in a spreadsheet, creating concept maps as a learning strategy); and digital citizenship (e.g., maintaining password security, identifying security risks, displaying an awareness of potentially inappropriate media use). Lau and Yuen (2014) found that female students in junior secondary school perceived their Internet literacy (e.g., searching information, using instant messaging, downloading files) and computer literacy (e.g., setting headers in word processing software, plotting a graph with a spreadsheet, editing a photo with image processing software) to be higher than that for male students.

In an earlier study, using the previous version of the ICT skill test used in this study, among Finnish upper comprehensive and secondary school level students, Kaarakainen et al. (2017) found that male students outperformed female students on tasks that required advanced information technology skills (e.g., tasks related to software installation and initialisation, information networks, server environments, programming, and database operations), while on tasks related to basic digital skills (e.g., basic operations, information seeking, word or image processing, social networking) gender differences were not significant. In the case of technology self-efficacy, males/boys often reported higher ratings than females/girls (see e.g., Huffman et al., 2013). For example, in their study on German secondary schoolers, Christoph et al. (2015) found boys' self-ratings (e.g., "I am able to install new programs…") and theoretical computer skills (e.g., terminological knowledge of basic computer-concepts, such as 'JAVA', 'IP-address' or 'FTP') to be higher than those for girls, while no gender differences could be found in basic computer skills (e.g., tasks related to digital contexts within web-browsers, text processing, and e-mailing).

It can thus be summarised that the question of gender difference in ICT skills is complex and still largely unclear. A notable problem is the variation in the used concepts and the diverse concept operationalisations. As Ritzhaupt et al. (2013) speculated, even though girls are successful in their studies, boys may still be more proficient in other ICT-related tasks not covered in their tests. Thus, more research is needed to identify the actual dimensions of the potential gender differences within ICT skills. This current study particularly aims to clarify this issue.

3 Methods

3.1 Participants

The data was collected in Finland at the beginning of year 2017 (January–March) as a project financed by the Finnish Prime Minister's Office (funding for Government's analysis, assessment and research activities). The participants were from 149 upper comprehensive level schools (grade 9/9) in 65 municipalities around the country, chosen based on a geographically representative sample of Finnish municipalities, as formed by the Finnish Education Evaluation Centre. Altogether, 5455 9th-graders ages 15 to 17 years were tested, and of that group 47% were boys and 53% were girls. The mean age for the participants was 15.24.

3.2 Measurement

ICT skills were measured using the online test developed in the Research Unit for the Sociology of Education (RUSE) at the University of Turku (Finland). The original ICT skill test was developed in 2013, and it was completely revised during year 2016 when the Finnish national core curriculum for basic education was renewed (2014) and implemented in schools in August 2016 (Kaarakainen et al., 2017; FNBE, 2016). The test is bilingual because both Finnish and Swedish are official languages in Finland. The software used for testing is a web application, written in PHP and Javascript and using the TinyMVC- and Bootstrap-frameworks. The application is supported by PostgreSQL database software for all data storage needs, and the test content (tasks and the specific questionnaires in each study) is included in the system as easily changeable XML-files.

The test consists of 18 items divided into 6 modules based on item topics (Appendix 1). The goal was to form coherent modules for a comfortable user experience. Test items were implemented in such a way that the user interface and graphics were intended to simulate common ICT applications and hence mirror real-life settings. The tested competency areas (18 items) were chosen based on the renewed Finnish national core curriculum (FNBE, 2016). The last module (requirements for the ICT study programs) was broadly based on the curricula for the ICT field of Finnish vocational institutions and the universities of applied sciences. The participants could achieve 2 points for each item, which could result in a maximum total score of 36.

In the ICT skill test, each item consists of multiple subtasks (1–6) and/or chains of actions, in which every action (selection or operation) is linked to the previous one; together they form a coherent item. In the items, a combination of close-ended questions (conventional multiple-choice, true-false multiple-choice, multiple true-false multiple-choice, and matching) (see Haladyna, 2011) and open-ended questions or questions requiring participants to interact with the test environment (input the right values or select and click the right function icons) were applied (see Siddiq et al., 2017). The majority of items can be seen as context-dependent item sets (see Haladyna, 2011), as they consist of a problem scenario that participants have to solve by choosing right actions from given options beside the progressive storyline. Some items can be seen as constructed-response questions that require the test-takers to construct or develop their own answers (Miller, 2015). In the ICT skill test, items are assessed automatically based on specified options and actions or simple text mining algorithms.

3.3 Analysis

The reliability (internal consistency) of the ICT skill test was estimated using Cronbach's alpha. Reliability refers to the extent to which a test is a consistent measure of a specific concept. It is known that scales with only two or three items tend to exhibit smaller alphas than do those with more items (Peterson, 1994). As the items of the ICT skill test can consist of only one multi-phase interactive task or just two or three subtasks, other item measures are utilised instead of alpha values for item level analysis.

The corrected item-total correlation is widely used to examine if any item fails to correlate with a total score. The cut-off value of .3 means that items that have item-total correlation below the threshold value are likely to be extremely easy or difficult or ambiguous, or otherwise that this item is not measuring the same construct being measured by the other items. (Nunnally & Bernstein, 1994.)

To analyse item difficulty, an item difficulty index was used instead of the proportion of right answers (traditional item difficulty), as that choice was better suited for complicated items (Tiruneh et al. 2017). Here the interest is not simply on how many test-takers get the item (completely) right. The formula used to compute the item difficulty index (P) was:

Difficulty index, $P = \frac{\sim f X - n X_{min}}{n(X_{max} - X_{min})}$

where $\sim fX$ is the total number of scores earned by all test-takers on an item, n is the number of test-takers, X_{min} is the smallest item score possible, and X_{max} is the highest item score possible.

Item discrimination is another basic measure of the validity of an item. It is defined as the ability of an item to discriminate (or differentiate) between high and low achievers. The formula used to compute the discrimination index (D) is:

Discrimination index, $D = P_U - P_L$

whereandare the difficulty indexes for the highest performing (U) and lowest performing (L) groups. The widely used threshold of 27% was used to divide these upper and lower groups. (Adams & Wiemanc, 2011.)

In order to respond to the research questions (Are there differences between the genders…? And what kind of differences are these…?), a two-tailed independent samples *t*-test was used to analyse the statistical differences between the genders. The *t*-test was used to compare the sample means from two *independent* groups for an at least *interval*-scale data when the distribution was approximately normal (see e.g., Warner, 2013). Analysis of the data was first executed using total scores of the ICT skill test, and then on each item separately in order to examine the gender differences in overall performance and also for each item one by one.

4 Results

The Cronbach's alpha for the ICT skill test (all 18 items) was .86, which clearly exceeded the threshold of .7 (Nunnally & Bernstein, 1994). Results of item-level analysis are presented in Appendix 1. As that appendix indicates, the item difficulty indexes varied from .01 to .61. Low- item difficulty indexes for the last four items indicated that all programming- related items were extremely difficult for the majority of 9th-graders. Even elementary programming, which actually does not require any programming skills, but only the ability to follow and give orders was based on the given instructions. The *P*-values for all other items lay within the range of ~.2 and ~.6, indicating that none of these items was either too difficult (<.2) or too easy (>.8) for the participants to complete.

The item-total correlation varied between .22 and .65. The items related to programming, which were among the most difficult items, also had the lowest item-total correlation values. The item discrimination indexes ranged between .34 and .92, and thus were all acceptable (>.3). These values indicated that all items on the ICT skill test were able to distinguish between participants who mastered the skills required for a particular item and those who did not yet have those skills.

Table 1. The ICT skill test scores by items and gender differences for the students.

	Altogether		Girls		Boys		The Independent Samples *t*-test	
Item	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t*-value	*p*-value
Information seeking	1.21	.45	1.29	.41	1.11	.47	15.086	.000***
Word processing	1.02	.82	1.18	.80	.84	.81	15.568	.000***
Software installation and updating	.93	.69	.90	.67	.95	.72	-2.427	.015*
Digital communication	.86	.62	.92	.60	.79	.63	7.961	.000***
Video and audio processing	.84	.68	.88	.67	.81	.70	3.770	.000***
Information security	.81	.58	.83	.57	.80	.59	2.182	.029*
Cloud services and publishing	.81	.69	.85	.68	.77	.69	4.142	.000***
Social networking	.77	.51	.80	.48	.74	.53	4.698	.000***
Image processing	.65	.57	.65	.43	.64	.49	.503	.612
Presentations	.56	.67	.63	.68	.48	.65	8.642	.000***
Spreadsheets	.51	.63	.57	.63	.45	.62	6.956	.000***
Software purchasing	.38	.43	.40	.42	.37	.43	1.920	.055
Basic operations	.36	.52	.23	.37	.52	.61	-21.579	.000***
Information networks	.34	.41	.23	.30	.46	.47	-21.104	.000***
Web programming	.15	.32	.11	.27	.20	.36	-9.556	.000***
Elementary programming	.12	.37	.09	.30	.17	.44	-7.862	.000***
Database operations	.10	.30	.07	.26	.13	.35	-7.486	.000***
Programming	.01	.13	.01	.09	.02	.16	-3.484	.000***

*** $p < .001$, highly significant
* $p < .05$, marginally significant

Table 1 presents the ICT skills test scores by items. The table is presented in descending order by the achieved average item scores of the students. The mean score for all test items for all participants was 10.45 (standard deviation 5.32), for girls 10.64 (SD 4.74) and for boys 10.24 (SD 5.92). The difference between the genders was small, but statistically significant (*t*-value 2.712, *p*-value .007). The five top scoring items for the students were information seeking (M 1.21), word processing (M 1.02), software installation and updates (M .93), digital communication (M .86), and video and audio processing (M .84). Conversely, the five lowest scoring items for the students were information networks (M .34), web programming (M .15), elementary programming (M .12), database operations (M .10) and programming (M .01).

There were only two items where the differences between the genders were not statistically significant, namely, image processing and software purchasing. In the case of software installation and updates, and information security, the difference between girls and boys was only marginally significant ($p < .05$). In the case of all the other items, the differences between the genders were highly significant ($p < .001$).

The girls significantly outperformed the boys in information seeking, word processing, digital communication, video and audio processing, information security, cloud services and publishing, social networking, presentations, and spreadsheets. The boys in their turn outperformed the girls in software installation and updating, basic operations, information networks, web programming, elementary programming, database operations, and programming. The widest gender differences in item mean scores were found in word processing (for the girls, with a difference of .34 points), basic operations (for the boys, with a difference of .29 points), information networks (for the boys, with a difference of .23 points), and information seeking (for the girls, with a difference of .18 points).

5 Discussion

In this study, the ICT skill test was introduced, and the results of the reliability and item analysis were presented to assess the quality of the test items and the test as a whole. The results indicated that the ICT skill test was a reliable instrument, and its items were mainly adequate in their difficulty level and had appropriate discrimination power. Both item difficulty indexes and item-total correlation for elementary programming, database operations, web-programming and programming items indicated the need to consider renovation of these items. It is clear that these four programming-related items are challenging for a comprehensive school final graders. However, since August 2016, programming has been integrated into the Finnish national core curriculum. In the upper grades (7–9/9) programming has been integrated as part of the objectives set for mathematics, while in the lower grades, the fundamentals of programming can be taught in all subjects (FNBE, 2016). Because of this these programming-related items should remain a part of the ICT skills test, as they provide the ability to track whether the desired programming skills will increase in the future or will not.

Based on our results, upper comprehensive level students performed best in schoolwork-oriented items, such as information seeking and word processing. Conversely, the lowest scoring items for all participants were technical-oriented items, such as basic operations, information networks, different kinds of programming, and database operations. The discovery that students performed relatively well on items related to word processing, computer security, social networking and communication is encouraging in light of the desire to achieve the learning goals of transversal competences in the Finnish national core curriculum (FNBE, 2016). On the contrary, the noticed lack of basic operational skills and knowledge deficits in information networks, spreadsheets, and software purchasing indicated the need for formal education on the very elementary use and knowledge of computers and mobile devices. It should also be noted that relatively low scores on the basic operations items, which relate to the technical usage of computers, can be explained to some degree by the fact that these items stress the use of computers and keyboards when Finnish youth today are more experienced with Smartphones or other mobile devices (see e.g., Taipale, 2014). For example, the use of shortcut keys (a subtask in the basic operations item) requires computer specific knowledge.

The current study answered the question on whether there were differences between the genders in ICT skills. Based on the analysis in this study, there was only a small, but still significant, difference between the genders in the total scores of the ICT skill test. Particularly, this paper sought to identify the actual dimensions of potential gender differences within ICT skills. When examining item level differences, the results are in line with previous studies (e.g., Aesaert & von Braak, 2015; Lau and Yuen, 2014), as girls were found to outperform boys, particularly on items that related to using learning-related software and tools like word processing, spreadsheets, presentation software, image processing, and items related to communication, social networking, and security issues. In contrast, in this study, boys were found to perform significantly better compared to girls on items that required more technical knowledge, like basic operations, information networks, programming, and database operations. This result is also in line with previous studies (Kaarakainen et al., 2017; Christoph et al., 2015). Above all, these discoveries emphasise that gender differences in ICT skills are particularly item specific.

Students' success was found to be weakest on the last module (requirements of ICT study programs) of the ICT skills test. This is also the module where the boys outperformed the girls by the largest margin. This module contained items related to database operations, web programming, and computer programming, which are common areas of computer science studies in secondary and tertiary level education. It is well known that in the field of computing, a lack of diversity has existed for several decades, and female participation in computing studies has remained low (McGill et al., 2016). However, after more profound consideration, this is the module that distinctly revealed that differences between individuals outweigh the difference between genders, as even among the boys, there was a huge variation in individual performance. It is worth noticing that the standard deviations for the scores on the items in the last module were at least twice as big as the mean. In fact, there were only 19 boys and 3 girls among all the participants, who got at least half of the available points in that module. Therefore there was only a very small group of students who mastered the most technical items in our ICT skills test, and this success related more to individuals than gender as such.

Individual technology usage habits and experiences played a notable role in the above-mentioned phenomenon. As Aesaert and von Braak (2015) assumed, the reason behind females' success in communication-oriented activities and information delivering can be found in their ICT use and experiences. Similarly, Lau and Yuen (2014) presumed that because female students tend to engage in more learning- and social networking-related activities at home, they achieve skills like information searching, instant messaging, word processing, image editing, etc., which were classified in their study as Internet and computer literacy. When it comes to more technical skills, Huffman et al. (2013) found that gender roles in particular (not just biological sex) play a large role in technology self-efficacy; in particular masculinity is a strong predictor of technology self-efficacy.

As van Laar et al. (2017) suggest, ICT skills are essential for performing tasks that are necessary in a broad range of occupations in a digital society. Typically ICT skills delivered in an educational context will have relevance also in 21st century digital skills for work. However, as van Laar et al., (2017) summarised, the changing labour market and job demands in a knowledge society pose serious challenges to educational systems, when they are asked to prepare students for jobs that may not yet even exist. In the Finnish core curriculum for basic education these ICT skills are decentralised under traditional school subjects (FNBE, 2016). This creates a situation where the responsibility for teaching ICT skills is fragmented between several teachers, at worst without adequately expressed and internalised common goals. This scenario increases the risk that not all students are getting sufficient digital preparedness for the future in their basic level education. All things considered, however, the notable role of individuals' (leisure time) experiences and usage habits in ICT skills and digital preparedness, when combined with decentralised teaching of those skills, may compromise the ideal of equality between the genders and principally between individual students. This raises important questions to study in future research.

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Appendix 1. The Modules and items and results of item analysis of the ICT skill test.

Module/item	Description	Item Difficulty Index, P	Item Dis-crimination Index, D	Corrected Item-Total Correlation, r
Basic use				
Basic operations	Participants have to pair a keyboard shortcut with a correct action and choose a correct type of computer memory for present education situation.	.18	.63	.40
Information seeking	Participants have four cases where they have to choose a correct source/channel, out of three, on where to further seek information on a given topic. After this, they are presented with list of search engine results and are asked to choose relevant items related to given scenario.	.61	.55	.38
Information networks	Participants are given four network usage scenarios and have to pair them with correct data transmission technologies and then match correct descriptions of computer network-related concepts.	.17	.57	.33
Productivity software				
Word processing	Participants are asked to edit (bold, italicise, underline and highlight) a given sample text.	.51	.72	.49
Spreadsheets	Participants are asked to fill a spreadsheet table with given information, bold a header row, and sort the table in ascending order.	.26	.79	.50
Presentations	Participants are given a general user interface view of presentation software, with essential sections marked. The task is to pair a correct name with the right section of this view.	.28	.83	.50
Social networking and communication				
Social networking	Participants have to pair correct social networking services with four service descriptions, define the meaning of social networking service, and choose four items out of nine that relate to the security of social networking services.	.39	.75	.59
Communication	Participants have to fill in the receiver fields, carbon copy, and blind carbon copy) of an email and add an attachment according to instructions, and identify the types of information that can be used to identify Internet users.	.43	.85	.65
Information security	Participants have to choose correct statements for secure network	.41	.80	.65

	communications and choose from alternatives those that are related to the information security of computers in an Internet cafe abroad.			
Content creation and publishing				
Image processing	Participants have to select correct image processing tools for cropping an image and make the person appearing in the image unrecognisable. Afterwards, participants have to choose correct image processing using related statements from given options and choosing the correct file formats for vector graphics.	.33	.67	.61
Video and audio processing	First, participants have to choose those methods that can be used to edit video footage from a single camera and then choose a right answer to the question: "Which one of these alternatives is related to lossy audio compression?".	.42	.95	.64
Cloud services and publishing	In the first step, participants have to choose which of the given statements about cloud services are true. In the second step one must choose the correct YouTube-video sharing option that enables limited sharing even to those who do not have an account on YouTube. The third step is a continuation question: "Can we now be certain the video does not circulate to the rest of the Internet for outsiders to see [...]?"	.41	.93	.56
Applications				
Software purchasing	Participants have to choose which matters need to be considered when evaluating the information security of mobile applications and also choose the correct definition of personal data protection from four alternatives.	.19	.58	.45
Installation and updates	In the first step, participants choose whether a statement is about an installation or an upgrade and in the second step, they choose whether a statement is related to an update or an upgrade.	.47	.92	.56
Elementary programming	Participants have to write, per instructions, a maze traversing script that leads from the starting point to the end. Then they have to write the value of a variable after the given pseudo-code has completed.	.06	.57	.40
Requirements for the ICT study programs				
Database operations	Participants have to form an SQL-query, based on given instructions and a simple	.05	.51	.20

	database diagram, then choose the right definition for the concept 'NoSQL database'.			
Web programming	Participants are given three files (HTML, CSS and JavaScript) to use to create a website and the view generated by these files. Participants then answer four multiple choice questions to edit the simple web page view and the dependencies between these given files.	.08	.34	.23
Programming	The programming task requires the participants to place lines of Java code in the correct places based on given comment sections.	.01	.44	.22

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Seeking Adequate Competencies for the Future:
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SEEKING ADEQUATE COMPENCIES FOR THE FUTURE:

The Digital Skills of Finnish Upper Secondary School Students

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Digital skills are a prerequisite today for working, studying, civic participation, and maintaining social relationships in our digitalised technical world. These skills are also important both as a general goal and an instrument for learning. This study briefly presents the aims that are related to digital skills of the Finnish curricula, and explores, using a large sample (N = 3,206) of Finnish upper secondary school students, these young people's digital skills and their distribution. The study provides new insights into the state of these skills and differences found in them and focuses on the relationship between these results and the students' present educational choices and future study/employment intentions. The actual variability of digital skills among upper secondary students is one of the main findings of the study. On the same educational level, it was found that digital skills vary enormously, particularly for students' current educational choices and their future intentions. Digital skills are also distinctly associated with age for 15 to 22-year-olds. At the same time, gender appears to have no prominent effect on the level or adeptness of upper secondary school students' digital skills.

Keywords: digital skills, upper secondary education, curricula, educational choices, gender

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Introduction

Global trends in rapid technological development and the rise of the digital economy have produced new kinds of competence requirements. Increasingly nearly every job, every level of study, and every field of education, civic participation, and communication and social relationships require at least a reasonable degree of digital skills. This technological development has altered the character of both civic skills and jobs. The new digital economy offers new opportunities and ways to work, but it also requires new combinations of skills and the ability to constantly improve them. In its first phase, digitalisation replaced routine manual work and then manual non-routine tasks. Now it also affects cognitive routines and non-routine tasks and is rapidly displacing lower-skilled workers. Jobs with higher complexity and higher skills requirements are more resilient, and these changes in the labour market have benefited the most skilled workers, particularly for non-routine and cognitive tasks. (European Commission 2016b; Nübler 2016; Levy et al. 2012.) The future labour market will be seeking digitally intelligent workers to cope with emerging, complex, and interactive assignments (van Laar et al. 2017). At the same time, citizens in a digital society are expected to have the skills and knowledge to be able to engage well with digital public services and all ranges of information. Indeed, Smart Cities expects Smart Citizens (e.g., Janowski 2015; Cocchia 2014), as they are described as being in highly technologised environments that use information technologies to adapt to changes in different physical circumstances and easily engage with local people using open innovation processes and e-participation (e.g. Komninos 2013).

There have been numerous efforts to predict the changes in civic life and the labour market brought about by this new technology. However, it has turned out to be difficult to predict specific future professions, so researchers and policy makers have instead sought to outline the skills believed to be required for the future (van Laar et al. 2017; European Commission 2016; 2016b; Davies et al. 2011). According to Davies et al. (2011) the ten most crucial skills for the future workforce are sense-making, social intelligence, novel and adaptive thinking, cross-cultural competency, computational thinking, new-media literacy, transdisciplinarity, a design-mindset, cognitive load management, and virtual collaboration. Many of these future skills are also associated with versatile digital skills.

Van Deursen and Mossberger (2018) remind us that the potential benefits of ubiquitous technologies and digitalisation are accompanied by social costs that include widening inequalities, not only in the labour market, but also in digital citizenship. Users with inadequate skills are less likely to benefit from opening opportunities, are less empowered to make decisions on their own within complex digital services and platforms, and may even suffer a loss of privacy. Ideally, digital citizens possess new forms of information skills and data literacy, including the ability to access, interpret, assess, manage, and use data, the skills to both communicate on social platforms and understand different forms of communication, and the strategic skills needed to make security and privacy control decisions effectively. According to van Deursen and Mossberger (2018), digitalisation may also deepen certain inequalities through the greater use of big data and analytics, for example, those being used for hiring, credit, insurance, health care, and service access. The risk, therefore, rests in the non-representative data (which excludes minorities) behind such automatic decision-making, and these can reinforce existing biases, by producing a false illusion of objectivity (O'Neil, 2016).

When it comes to digital skills, the definitions, viewpoints, and frameworks used in previous studies are numerous. In most cases, these concepts consist of a domain part (such as a computer, ICT, or Internet) and a knowledge perspective (competence, literacy, or skills) (Hatlevik et al. 2015). Van Laar et al. (2017) argue that the current concepts in this area are increasingly taking into account knowledge- or content-related skills that are intending to widen the traditional dominance of technologies in concepts like digital or ICT competency. Van Dijk and van Deursen (2014) recommend using the term "digital skills" as it captures the entirety of transferable skills that are needed for one to be able to use digital media and services successfully in a digitalised society.

As Hoffman and Schechter (2016) point out, digital skills will become a key prerequisite for civic participation, social communication, information searching and processing, academic skills and professional success in future societies. According to Berger and Frey (2016), although all kinds of digital skills are expected to increase in importance in the future, there is a particularly growing demand today for more advanced technical skills in the labour market. This focus makes digital skills necessary for both success and overall professional well-being in a digitalised world. Consequently, digital skills should be considered as desired, even necessary, educational outcomes that students must work to achieve. These skills also need to play a central role in curricula at every educational level. (Aesaert et al. 2015.) This paper thus discusses digital skills in the context of the Finnish curricula, examines the digital skills of Finnish upper secondary school students and indicates how these skills are associated with current students' educational choices, future study/employment intentions, genders, and ages.

Digital Skills and the Finnish Curricula

In the Finnish education system, the upper secondary level is divided into general and vocational upper secondary education, and both provided an opportunity to continue on to the tertiary education level. Upper secondary school students in Finland are increasingly expected to use digital technologies and the Internet when seeking information, preparing texts and presentations, undertaking cooperative learning and communication in school and for homework (e.g., FNBE 2016; FNBE 2012). In Finland, digital skills and information technology skills are not included as a subject of their own in the national core curriculum offered in general and vocational upper secondary education. Instead these skills are taught as part of all separate subjects and study modules (FNBE 2016; FNBE 2012).

In the core curriculum of Finnish general upper secondary schools, digital skills are one of the six transversal competence areas designated as Technology and Society. These skills are targeted to use to overcome educational challenges in the present society and thus implemented in all subjects. The goals are to deepen students' abilities to appropriately use and interact with digital technologies in a responsible, safe, and ergonomic manner – both independently and with others. Students are offered different possibilities to examine and evaluate, for example, topics in the following themes: Technological development and its effects and potentials, the human computer relationship, technological impact and its role for the evaluation of lifestyles, and the interaction of science, art and technology. Further still, the learning goals encourage students to use their potential, creativity, and problem-solving skills to seek and find solutions to hands-on challenges, promote the understanding that mistakes are a part of the creative learning process, enhance cooperation skills, gain experience in entrepreneurship and technology enterprises, develop the competencies needed to make reasonable choices as both citizens and consumers, and gain the abilities to evaluate the interactions between technology, the economy, and public life, and the technological impacts to produce successful occupational restructuration. In addition, the advanced syllabus in mathematics includes a specialised course in algorithmic thinking. (FNBE 2016.)

In Finland, vocational upper secondary education covers 8 fields of education, including more than 50 vocational qualifications. These studies are comprised of both compulsory and optional study modules. (FNBE 2013) The curricula in vocational education consist of a common part for all the fields of vocational education and training and then a qualification specific segment of the curriculum. Technology and information technology skills are seen as a key competence for lifelong learning. The goal is for all students to gain various experiences in the technologies that are used in their profession, have knowledge of all related technological benefits, limitations, and risks, and become versatile users of computer technology as both a professional and a citizen. Digital skills are thus part of the key competencies that are common to all vocational fields. (e.g., FNBE 2012; FNBE 2011a.)

Within this common qualification that is delivered to all the fields of education, digital skills are the study modules for mathematics and natural sciences (e.g., the use of applications, security, and network identity issues, receiving and giving commands, saving and sharing files), communication and media skills (e.g., information and media skills, digital communication), and active citizenship and knowledge of different cultures (e.g., social media and civic participation, e-government services and consumer skills, digital skills for job applicants) (e.g., FNBE 2012; FNBE 2011a). In addition, within these ICT- or technology-related qualifications, the qualification specific part of the curriculum includes program specific study modules, for example, knowledge of the process that occurs from software implementation to software specification and design and the integrated applications for understanding server systems (FNBE 2012; FNBE 2011b).

These curricula provide a foundation on which the skills of future citizens and workers in Finland are built. According to the Official Statistics of Finland (OSF 2016a), a fair 50 percent of students continue on to general upper secondary education and about 40 percent continue on to vocational education immediately after completing their basic education. Less than 10 percent of young people opt out or drop out of their secondary education studies each year. After the secondary level, 37 percent of those who have completed their qualifications in general upper secondary schools in year 2016 continued their studies at the tertiary level or in other forms of education within one year after graduation. In contrast, for the graduates from vocational secondary school, those who are still full-time students one year after graduation only totalled 8 percent. Even though the graduates of general upper secondary school continue their studies on the tertiary level at some point in their lives, for many of these young people, upper secondary school is the last venue where they receive any formal training in digital skills. This knowledge stresses even further the clear importance of reaching an adequate level of these skills during upper secondary level studies, and, this fact should be noted in the curricula of every study program at the secondary education level. Secondary level education is the last chance to reach the majority of each age group and ensure that the adequate skills they need to be a citizen in a digital society and a labour market entrant in today's highly technologised labour market are effectively delivered.

The Digital Skills of Upper Secondary School Students

It has too often been taken for granted that young people possess the competencies they will need to proficiently utilise digital technologies (i.e., Bennett et al. 2008). However, many of the previous studies (e.g., Kaarakainen, Kivinen & Vainio 2018; Kaarakainen, Kivinen & Kaarakainen 2017; van Dijk et al. 2014; Calvani et al. 2012) have learned that this optimistic portrayal of young persons' digital skills is poorly founded. Whereas at the basic education level, the focus of teaching digital skills is to offer students experience with computers and teach some operational skills, at the secondary education level, this instruction focus transfers to content-related digital skills, and indeed pronouncedly, to information skills. Students receive assignments that require the use of the Internet independently for sources. Yet, too often, teachers tend to forget that the general digital skills of secondary education level students are commonly insufficient, and these students need more instruction on these skills. (Van Dijk et al. 2014.) Anzera and Comunello (2014) emphasized that despite the general belief ("surely everyone knows how to google"), information skills are complex by their very nature and cannot be properly or fully acquired without some direct teaching of them. The same is true for general digital skills. Van Dijk and van Deursen (2014) argue that in post-basic level studies, before using any digital technologies for educational purposes, a student's level of digital skills should first be tested. Unskilled students need to be taught the precise skills they need before they can simply be assumed to be able to independently cope with all of the typical digital technologies and digital learning environments.

The systematic review of Siddiq et al. (2016) targeted the finding of having a comprehensive picture of the present state of the field of digital competence assessment in the contexts of both basic and secondary level education. They found that the majority of assessment tools were used with lower secondary level students, and there was a lack of assessment instruments; therefore, only a few of the previous research results, particularly regarding upper secondary level student skills. Based on their analysis, of the majority of assessment tools that measured students' skills related to managing digital information, only a fair half of these tools also measured the skills related to content-creation, digital communication and technical operations. Further, only a few of the assessment tools measured the competence areas that require strategic skills, such as safety or problem-solving (Siddiq et al. 2016.)

As addressed by Siddiq et al. (2016), there are currently not a large number of available studies that relate to upper secondary school students' digital competence. However, these available previous studies do indicate that upper secondary school students lack many of the skills they will need in today's digital environments. For example, in their study, Calvani et al. (2012) showed that Italian upper secondary school students mastered visual literacy (e.g., they could identify menu bars and computer signals) and troubleshooting (e.g., they knew what to do when audio was not heard or a printer did not work) quite well. However, for those tasks that required critical cognitive and socio-ethical skills, these same students' knowledge and competence was found to be inadequate. These results were similar to the observations made by van Dijk and van Deursen (2014), who assumed that young people have adequate medium-related skills (i.e., button knowledge), but they lack particular content-related skills (i.e., information, content creation, and strategic Internet skills.)

Studies of Finnish secondary and upper secondary level students do not unambiguously support the aforementioned assumptions. Instead, previous studies done of Finnish students have indicated that this group of young people have technical or operational skills that are highly overestimated. These students were found to perform satisfyingly on schoolwork-oriented items (e.g., information seeking and word processing), but failed to do the same on technical-oriented items in particular (e.g., basic operations, information networks, different kinds of programming, and database operations) (Kaarakainen et al. 2018; Kaarakainen et al. 2017). This inadequacy in technical-oriented or medium-related skills was due to the fact that the majority of Finnish youth today are well experienced with easy-to-use Smartphones and other mobile devices, but they are not experienced enough in using devices with a wider range of technical capabilities (Kaarakainen, et al. 2017). Another reason for this difference is the major role that self-learning is now playing to deliver these skills to many young people. As van Dijk and van Deursen (2014) argue, learning these digital skills outside of formal education results in acquiring only those skills that are urgent to use at a particular moment. This kind of learning is likely to be only partial, and indeed, many related operations, principles, techniques and applications are simply bypassed for the sake of convenience.

This large variation in digital skills of upper secondary school students has been addressed in previous studies (e.g., Authors et al 2017a; Hatlevik et al. 2009). Hatlevik and Tømte (2009) also found in their study that the Internet safety awareness of Norwegian upper secondary school students varied between schools, classrooms, and students; students' social backgrounds were also a factor in determining their safety awareness. Based on yet another study of Norwegian students in upper secondary level education, both cultural capital and language integration were positively associated with digital competence, meaning that digital competence is at least to some extent distributed across family backgrounds. In the same study, it was also found that self-efficacy and strategic information use predicted these students' digital competence. Further, student academic achievements were found to predict the actual level of digital competence. (Hatlevik et al. 2015.) Earlier, Hargittai (2010) showed that there is a great variety in Internet usage and the skills of young people, and both aspects are not randomly distributed. Rather, higher levels of parental education, being a male, and other socio-economic factors were positively associated with higher levels of web-usage skills. Van Deursen et al. (2011) found that among the common explanatory variable candidates of the same age, gender, and education, educational attainment was the most significant predictor for both medium- and content-related digital skills. More educated people outperformed lesser educated people.

The Survey of Adult Skills, known as the PIAAC (OECD 2016), examines literacy, numeracy, and problem-solving in technology-rich environments, including the skills of 16–24-year-olds. The section on Problem solving in technology-rich environments focuses on skills that are needed in a digitalised society for personal, work-related and citizen-related situations. Both problem-solving and basic computer literacy skills are measured by testing how well test-takers are able to use ICT tools and applications to assess, process, evaluate and analyse information in goal-oriented situations. Based on PIAAC results, young adults (ages 16 to 24) in Finland possess a higher proficiency in technology-related problem-solving compared to the total Finnish adult population. In general, the results among Finnish adults indicated that education had a significant relationship to all measured skills, and those who had taken part in general upper secondary education succeeded significantly better than those who attained skills in vocational upper secondary education. This effect was particularly strong for the skills needed in problem-solving in technology-rich environments (OECD 2012; 2016). Correspondingly, Brunello and Rocco (2017) argued based on the PIAAC data from 17 countries, that the level of proficiency in basic skills revealed that vocational education is less effective than academic education at the same level of education.

Similarly to the above-mentioned research, a previous study of Finnish upper secondary school students (Kaarakainen, et al. 2017) indicated there are also significant differences within the same educational level in students' digital skills, as average students in the general upper secondary schools possessed stronger digital abilities than did those students in vocational upper secondary schools. Still, as mentioned earlier, in Finland, vocational education has several fields of education, and these skills presumably vary a lot for each vocational student depending on the study programmes. Thus, in this current study, this variety of study programmes in vocational upper secondary education was taken into account. Overall, this study sought to explore the digital skills of Finnish upper secondary education students by age, gender, not just current educational choices, but also future study/work intentions. The research goals for this study, therefore, are the following:

1) Examine the level and variation in digital skills for upper secondary school students
2) Analyse the relationship between upper secondary school students' digital skills and their gender, age, current educational choices, and future study/employment intentions

Methodology

Participants

The data for this study were collected in Finland during the year 2017 as part of a project financed by the Strategic Research Council (SRC) at the Academy of Finland. The participants came from 43 municipalities (88 educational institutions) around the country and consisted of 3,206 upper secondary level students between the ages of 15 and 22. Mean age of the participants was 16.73 with a standard deviation of 1.23. Of the participants, 69 percent came from general upper secondary schools, and 31 percent came from vocational institutions. Table 1 summarizes the frequency of these participants by educational choices and gender. In general, a fair 50 percent of Finnish students continue on to general upper secondary education and about 40 percent of those continue on to vocational upper secondary education immediately after completing their basic education (OSF 2016b). Thus, general upper secondary school students were overrepresented in terms of their share of the total population in this current data set. Of the participants from general upper secondary schools, 64 percent were female students, and 36 percent were male students, whereas in the vocational schools, 55 percent of the students were male, and 45 percent were female.

TABLE 1

Educational Choices	Female Students	Male Students
General upper secondary education:		
Basic syllabus in mathematics	627	276
Advanced syllabus in mathematics	778	520
Vocational upper secondary education:		
Culture	26	6
Natural sciences (ICT)	2	20
Natural resources and the environment	3	26
Tourism, catering, and domestic services	81	30
Social services, health, and sports	173	16
Technology, communication, and transportation	58	377
Social sciences, business, and administration	112	75

Table 1: Frequency of participants' educational choices and their designated genders.

Measurement

The data were collected using an instrument called the ICT skill test that was developed in the Research Unit for the Sociology of Education (RUSE) at the University of Turku (Kaarakainen 2018). The test starts with questionnaires that collect the students' background information (age, gender, postal code, and education level), current educational choices (general upper secondary school or vocational institution, whether the student was a general upper secondary school student participating in a basic or advanced syllabus in mathematics or not, and if the test-taker came from a vocational upper secondary school, was she/he studying culture, natural sciences (ICT), natural resources and environment, tourism, catering and domestic service, social services, health and sports, technology, communication and transport, or social sciences, business and administration).

Voluntary digital activity was gathered as usage activity for the following specific purposes: Maintaining social relationships, communicating, running daily errands, following the news, searching for information, creating digital content, sharing digital content, playing digital games, consuming digital entertainment, and studying using digital technology. Schoolwork-related digital activity (use of devices, online services and software and digital educational materials for learning at school), and the participants' future intentions were also compiled (the field (ISCED-F) for where they desired to study or work after graduating from their current educational plan). In this study, only their demographic information, current educational choices and future intentions were analysed concurrently with the test performance information.

The actual test was undertaken after the questionnaires were completed. The ICT skills test consisted of 18 items (see Appendix 1) divided into 6 modules based on item topics (see Figure 1). Each item consisted of multiple subtasks (1–6) and/or chains of actions in which every action (selection or operation) was linked to the previous one; together they formed a coherent item. For these items, a combination of close-ended questions (conventional multiple-choice, true-false multiple-choice, multiple true-false multiple-choice, and matching) and open-ended questions or questions requiring the participants to interact with the test environment (input the right values or select and click the right function icons) were applied (see examples in Figure 2). The majority of these items can be seen as context-dependent item sets (cf. Haladyna et al. 2002), as they consist of a problem scenario for the participants to solve by choosing the right actions from given options related to a progressive storyline. In the ICT skills test, the interest is not simply on does the test-taker get the item completely right, but how much of each item requirements test-taker masters. Scores for each item ranged from 0 to 2 resulting in a total score of 36. Items were assessed automatically based on specified options and actions or simple text mining algorithms.

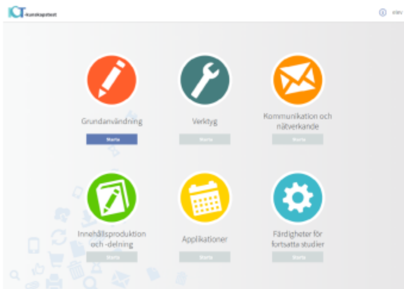

Figure 1: Six modules (basic operations, office tools, communication and networking, content creation, applications, and prerequisites for ICT-related studies) of the ICT skills test (all print screens are from a Swedish user interface)

The test items were implemented in such a way that the user interface and the graphics attempted to simulate common ICT applications and hence mirror real-life settings. The test was bilingual, as both Finnish and Swedish are official languages in Finland. The ICT skills test was implemented as a web application, written in PHP and JavaScript languages, using the TinyMVC- and Bootstrap-frameworks. That application is supported by PostgreSQL database software for storage purposes. The tested competence areas (15/18 items) were chosen based on the Finnish national core curriculum for basic education, wherein digital skills are one of seven transversal competences that are integrated into all subjects so as to offer every student the following skills: Understanding of the basic operations and concepts of ICT, the knowledge to use ICT in a responsible, safe, and ergonomic manner; the abilities to use ICT as a tool for information management and creative work; and the competence to use ICT for both interaction and networking (FNBE 2016). The last three items are broadly based on the curriculum of the information and communications technology field in Finnish vocational upper secondary schools and the Universities of Applied Sciences. The Cronbach's alpha for the ICT skills test (all 18 items) was .86, which exceeded the common threshold of .7 (Nunnally et al. 1994). The results of a more specific item-level analysis were presented in a previous study (Kaarakainen 2018). In this current study, however, the ICT skills test scores are only considered at the total score level.

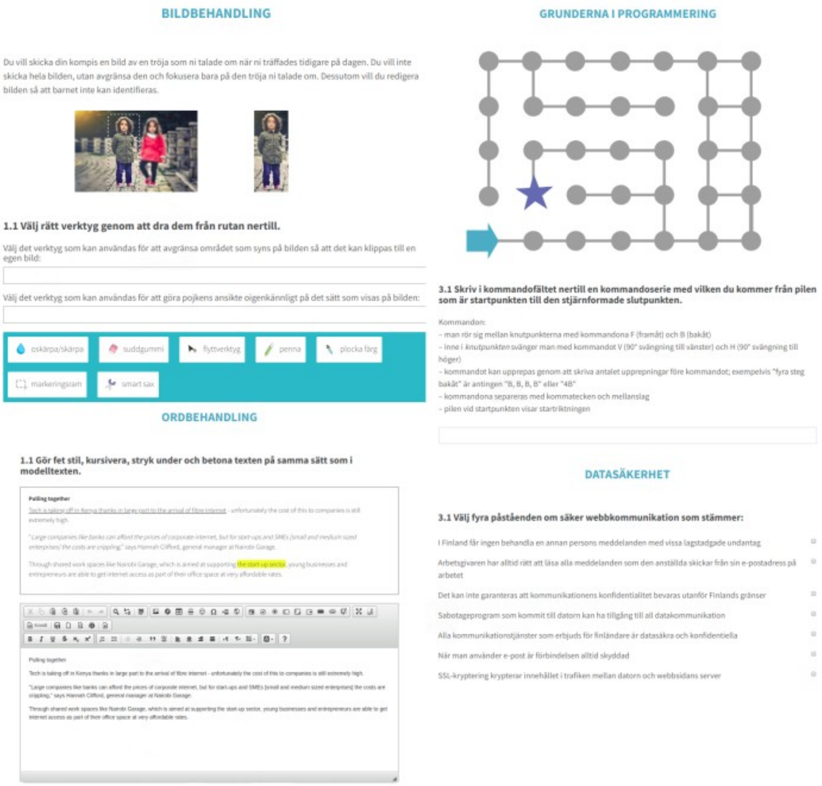

Figure 2: Examples of items: a matching type multiple-choice item (top left; image processing), an open-ended item (top right; elementary programming), an interactive item (bottom left; word processing) and a true-false multiple-choice item (bottom right; information security) used on the ICT skills test (see item requirements in English in Appendix 1).

Analysis of the Data

The first research goal addressed in this paper, namely, the level and variation of upper secondary school students' digital skills, was answered by examining the variable range, means and standard deviations, and the differences between the genders for these scores. These scores were analysed by using an independent samples t-test, as it is a suitable test to use to compare the sample means from two independent groups for at least interval-scale data (see e.g., Warner 2013). A Chi-squared test was utilised to test the differences between the genders in popularity of the fields for both current educational choices and future study/work. The Chi-squared test is a common statistical hypothesis test used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in one or more categories being tested (Greenwood et al. 1996). The associations between students' current educational choices and their future study/employment intentions using digital skills were examined by analysing first the test scores by study programmes or by future intentions (ISCED-F fields) and then further case-by-case by gender. One-way analysis of variance (ANOVA) was used to test the differences between the study programmes. ANOVA is a common statistical method used for comparing three or more group means. If the ANOVA is significant, then a post-hoc comparison between these same groups is necessary to identify the specific significant differences between each pair of groups. In this study, pair-wise comparisons were conducted using the Bonferroni method. (Rupert 1997.) After comparing the means between different study programmes/future intentions, an independent samples t-test was used to test the differences between the genders within each specific study programme.

Multiple linear regression analysis was used to analyse the relationship between upper secondary school students' digital skills, gender, age, current educational choices, and future intentions. Multiple linear regression is an extension of simple linear regression. It allows one to answer questions about the kind of a role multiple independent variables play when accounting for any variance of a dependent variable (Nathans et al. 2012). This analysis was run separately for students in the general upper secondary schools (GUSS) and those in vocational schools (VUSS) since the background variables for these students were different. The R-squared values for the following two models remained low: For general upper secondary school (13 variables) adjusted to $R^2 = .09$, and for the vocational schools (18 variables) adjusted to $R^2 = .22$. The low R-squared values do not mean that the regressors were inappropriate; it simply suggests that the models missed certain explanatory variables (Marsh et al. 2002), and the skills to explain a much more complicated group of factors than those examined in this study. The autocorrelation influence was assessed using the Durbin-Watson test. The Durbin-Watson statistic d ranges from 0 to 4, and should be near 2, as low d values (near 0) indicate a positive serial correlation; high d values (near 4) indicate that successive error terms differ from one another (Durbin et al. 1951).

Chasing a more accurate view of the associations of age, educational choices, and digital skills, the performance mean scores were separately visualised by age for the general upper secondary school students (GUSS) and the vocational upper secondary school students (VUSS). The differences between the students in these two groups at each age point were analysed using an independent samples t-test.

Results

The ICT skill test total scores ranged from 0 points to 32 points (maximum points on the test were 36) indicating that the variation in different students' skills was extensive. The mean score of all 18 items was 12.41 with a standard deviation of 5.74, meaning that on average, students achieved only one-third of the available points from the ICT skill test. The mean score for male students was 12.84 (SD 6.41) and for female students, 12.11 (SD 5.18), and the difference between the two was statistically significant ($t = -3.422$, $p = .001$). Further analysis revealed that the mean scores for the ICT skill test varied more between those students in different study programs than between the genders as shown in Figure 3. These differences, based on a one-way analysis of variance, between the different study programs were highly significant ($F(8, 3184) = 36.830$, $p < .001$).

Figure 3 shows the mean scores on the ICT skill test by gender and current educational choices. When examining the gender differences within educational choices, it should be noted that gender distribution in educational choices were significantly unequal for both the general upper secondary education mathematics studies ($X^2 = 23.285$, $df = 2$, $p < .001$) and fields of study in vocational education ($X^2 = 435.484$, $df = 6$, $p < .001$). Students from vocational upper secondary schools who studied vocational qualifications in information and communications technology (natural sciences (ICT)) performed best on the ICT skills test. Even when the bar of female students on the bar chart (Figure 3) were notably higher, the difference between the genders for the mean scores was not significant (see more of the details on gender differences in Appendix 2). This result was due to the unequal sample size (male dominance in the field of natural sciences), which reduced the statistical power (see Rusticus et al. 2014). The students from vocational upper secondary schools, who studied a field of culture (vocational qualifications in audio-visual communication) ranked second, and students from the general upper secondary schools, who studied an advanced syllabus in mathematics, ranked third. Among the audio-visual communication students, gender differences were not significant, but among the general upper secondary school students studying an advanced syllabus in mathematics, male students outperformed the female students (see Appendix 2). After the top three ranked in vocational upper secondary education came those students from the social sciences, business and administration and technology, communication and transportation study programs, and then general upper secondary school students who studied basic syllabus in mathematics. No statistically significant differences between the genders were found among these groups (see Appendix 2). Among the bottom three were vocational upper secondary school students from programs in natural resources and environment, tourism, catering and domestic services, and social services, health and sports studies. Again, there were no significant differences between the genders for any of these groups (see Appendix 2).

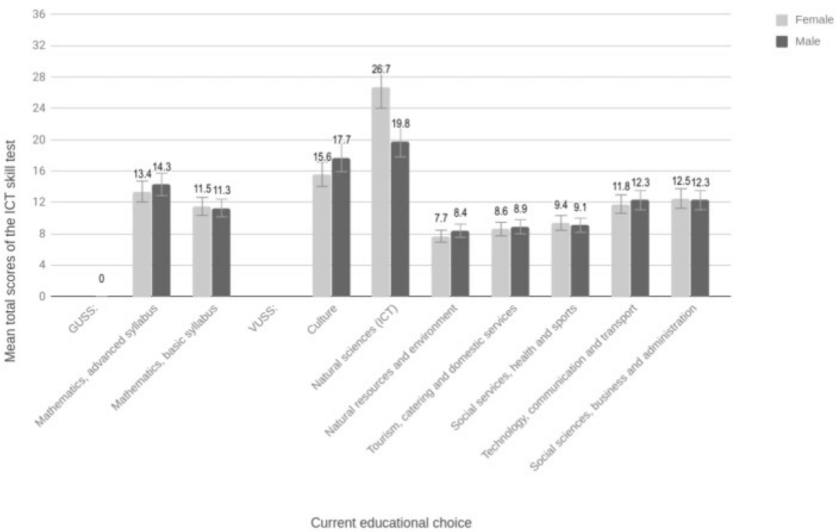

Figure 3: Mean scores on the ICT skill test by gender and current educational choices with error bars.

Figure 4 represent the popularity of fields of future intentions among students by gender. The Chi-square test indicated that among Finnish upper secondary level students there existed significant differences in the popularity of fields of future study/work between the genders ($X^2 = 776.389$, df = 9, $p < .001$), except in the field of business, administration, and law, which was popular for both genders and the fields of agriculture, forestry, fisheries, and veterinary, which in turn were unpopular for both genders. The most popular field for female students was health and welfare, whereas for male students, engineering, manufacturing and construction were clearly the most popular fields for future studies or work. Among the female students, the fields of business, administration and law, education, arts and humanities, and social sciences, journalism and information were also popular choices for future study/employment. On the contrary, the ICT field was the most unpopular choice among female students, and agriculture, forestry, fisheries, and veterinary ranked right after ICT in unpopularity. Among male students, the fields of business, administration and law, and ICT ranked next after engineering, manufacturing and construction. The most unpopular choices for males were social sciences, journalism and information, education, and agriculture, forestry, fisheries and veterinary.

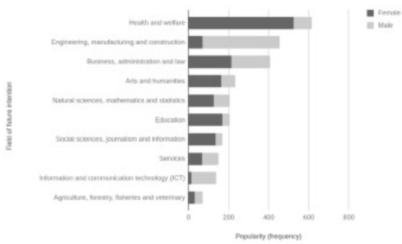

Figure 4. Student popularity of fields for future study or employment by gender.

Figure 5 indicates the mean scores on the ICT skill test by future study/employment intentions and by gender. The differences in digital skills between students with different future intentions were highly significant (ANOVA: $F(9, 2958) = 30.976$, $p < .001$), as students' aiming for ICT or other STEM fields outperformed the other students. In turn, digital skills were the most insufficient for those students' aiming to enter the fields of education, services and agriculture, forestry, fisheries and veterinary. Based on an analysis of an independent sample t-test, there were no significant differences between the genders among students within the same field of future intention, except for students' wanting to enter STEM fields. Within that student group, male students outperformed the female ones (see Appendix 3 for more details).

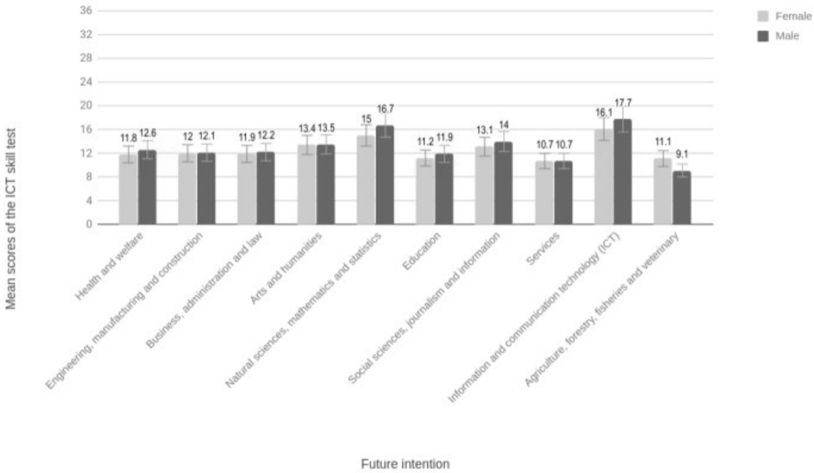

Figure 5: Mean scores on the ICT skill test by gender and current educational choices with error bars.

TABLE 2

	GUSS			VUSS		
Predictors	B	SE	β	B	SE	β
Gender (female = 0 / male = 1)	-.334	.260	.260	-.223	.459	-.018
Age	.604	.128	.098***	.781	.109	.207***
Current Educational Choices:						
Syllabus in mathematics (for GUSS only):						
Basic (= 0) / Advanced(= 1)	2.123	.241	.193***			

Studies in certain fields (for VUSS only):						
Culture				2.257	1.173	1.173
Natural sciences (ICT)				3.678	1.297	1.297
Natural resources and the environment				-1.449	1.500	1.500
Tourism, catering, and domestic services				-2.360	.786	.786
Social services, health, and sports				-1.358	.850	.850
Technology, communication, and transportation				1.220	.617	.617
Social sciences, business, and administration				1.309	.740	.740
Future Intentions:						
In the future, student wants to study/work in:						
Education	-.606	.559	-.030	-3.095	1.357	-.085*
Arts and humanities	.989	.548	.050	.035	1.229	.001
Social sciences, journalism and information	.912	.577	.042	-1.702	1.770	-.031
Business, administration and law	-.520	.798	-.031	-1.564	1.051	-.085
Natural sciences, mathematics and statistics	2.241	.557	.114***	3.033	1.783	.055
Information and communication technology (ICT)	3.961	.795	.116***	4.562	1.021	.204***
Engineering, manufacturing and construction	-.309	.550	-.016	-.802	.850	-.058
Agriculture, forestry, fisheries and veterinary	-1.390	1.016	-.030	-2.200	1.475	-.071
Health and welfare	-.199	.462	-.015	-2.064	1.113	-.116
Services	-.903	.519	-.051	-1.395	.882	-.097
R	.31			.48		
Adjusted R^2	.09			.22		
F-value	17.197***			16.334***		

B = the unstandardised beta, SE = the standard error for the unstandardised beta, β = the standardised beta,
* p < .05, ** p < .01, *** p < .001t

Table 2: Multiple regression models for general (GUSS) and vocational upper secondary school (VUSS) students.

Two separate multiple regression analyses were performed (see Table 2), one for general upper secondary school students and one for vocational upper secondary school students. Table 2 presents the results of the analysis of general upper secondary school students and vocational upper secondary school students and their respective data sets. This analysis showed that digital skills among general upper secondary education students were significantly predicted by age, an advanced syllabus in mathematics, and the intention to further study/work in STEM or ICT ($R = .31$, adjusted $R^2 = .09$, $F(13, 2187) = 17.197$, $p < .001$). The best predictor of digital skills among the general upper secondary school students was an advanced syllabus in mathematics (standardised beta coefficient, $\beta = .193$). Also the intention to study or work in ICT ($\beta = .116$) or a STEM ($\beta = .114$) field in the future, and age ($\beta = .098$) was associated positively with these students' digital skills.

For vocational schoolers, the analysis showed that digital skills were predicted by age, studying ICT (positive predictor) or tourism, catering and domestic services (negative predictor) and the intention to further study or work in the ICT field (R = .48, adjusted R^2= .22, F(18, 986) = 16.334, p < .001). The best predictors of digital skills among the vocational upper secondary school students were age (β = .207) and the intention to study or work in the ICT field in the future (β = .204). Further, studying the fields of natural sciences (β = .089) and culture (β = .079) increased the digital skills, whereas studying the tourism, catering and domestic services fields (β = -.124) significantly decreased these particular skills as well as the intention to study/ work in the field of education (β = -.085) in the future. The Durbin-Watson d value for the GUSS (1.553) and VUSS (1.573) models indicated no major problems with autocorrelation.

Figure 6 offers the ICT skills test mean scores by age and current educational choice. Before this analysis and visualisation, all students older than 19 were removed because there were no 19+ year old students in the general upper secondary schools, and only a few in the vocational upper secondary schools. In Finland, the typical graduation age from upper secondary education is 18 or 19. Vocational upper secondary schools usually have older students due to dropouts who later return to studies and the fact that some graduates from general upper secondary schools do continue their studies in vocational upper secondary schools instead of applying to the tertiary level. As was clearly seen, at the beginning of the upper secondary level at the age of 15, students in the general upper secondary schools outperformed the vocational education students (GUSS: M 12.37, SD 5.49; VUSS: M 7.97, SD 5.10; t = 5.629, p < .001). At the age of 18, there were no longer any significant differences between the school types (GUSS: M 13.74, SD 7.44; VUSS: M 13.58, SD 5.68; t = .100, p = .920) as the vocational schoolers had closed the gap during their three-year degree studies.

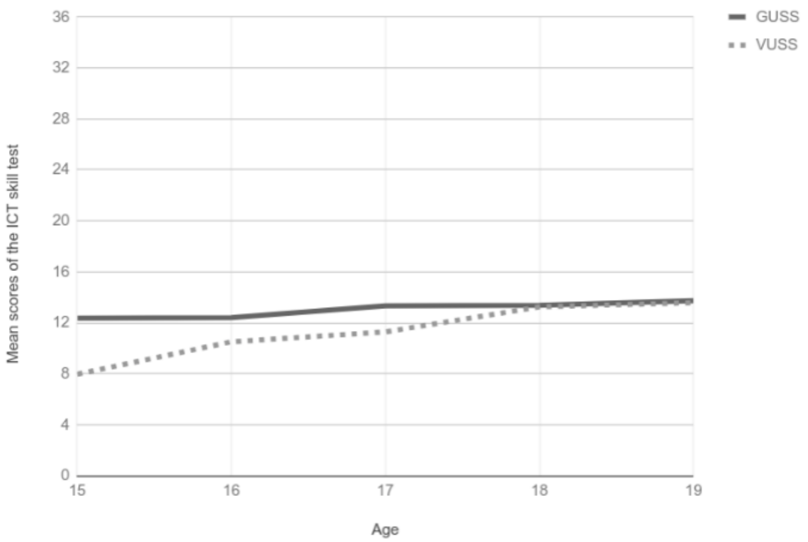

Figure 6: ICT skill test performance by age and educational choice.

Discussion

As mentioned earlier, Siddiq et al. (2016) noted that the majority of the present assessment tools were developed to measure digital competence for lower secondary level students; therefore, these authors encouraged researchers to develop tests for primary and upper secondary level students. This study and the developers of the ICT skill test accepted this challenge. The ICT skill test is specifically developed for upper secondary education students. The vast majority of tasks are, therefore, quite demanding, as the test is targeting satisfactory item level discrimination power between high and low performers aiming to expose potential uneven digital skills.

The variability of digital skills among upper secondary education students is one of the main findings of this study. At the same educational level, some students were not able to solve any of the presented assignments, while the most capable students successfully solved almost 90 percent of these tasks. The average performance level on the ICT skills test for Finnish upper secondary school students was relatively low, as these students had mastered on average only one-third of the skills being tested. This result is in line with the considerations of van Dijk and van Deursen (2014), who criticised the overestimation of young people's digital competences. The results also stress the need to focus on integrating digital skills into upper secondary level teaching, rather than simply relying on the assumptions that students already possess these skills when they transition from basic education to upper secondary education.

On average, the results of this study indicated that male students outperformed female students by a slight, but still a statistically significant margin. However, when the gender differences were analysed separately based on current educational choices and fields of future study/work intentions, gender had no prominent effect on the digital skills of the students. This finding was confirmed by regression analyses, wherein gender proved not to be the significant predictor of students' digital skills. On the contrary, current educational choices and the specific field of future study/employment intention had a notable impact on students' digital skills. Particularly the intention to work or study in ICT or other STEM fields in the future appeared to be associated with the current level of digital skills.

Among Finnish general upper secondary school students, current attendance in advanced syllabus studies in mathematics predicted higher scores on the ICT skills test. In turn, among vocational upper secondary school students, their current attendance in the culture or natural sciences predicted higher performance, while attendance natural resources and environment, tourism, catering and domestic services, or social services, health, and sports were associated with lower digital skills. The dominance of educational choices over gender, therefore, was in line with the previous results of van Deursen et al. (2011) according to which, among the common explanatory variable candidates, education was the most significant predictor of digital skills.

However, unlike what van Deursen et al. (2011) assumed, the cause of this particular observation is probably not the equalisation of education in terms of gender distribution, because as the results of this current study indicated, the gender distribution in students' current educational choices and future intentions was notably unequal. Among the highest performing natural sciences students, the under-represented female group succeeded at least as well as males did, while in turn, in the lowest performing female-dominated fields, male students possessed digital skills that were as weak as those among females. These results indicate that students with higher digital skills and an interest in the ICT sector drift toward particular study programmes at the upper secondary level. Thus, the actual cause of uneven digital competence originates in the previous level of education.

This phenomenon places extra pressure on basic level education, as it should ensure greater equality in digital skill development for all students. As van Deursen and Mossberger (2018) remind us, the potential benefits of digitalisation are accompanied by widening inequalities for those who are not well prepared. If the digital divide among young people cannot be moderated during their common basic education, these uneven opportunities accumulate further during their upper secondary education studies and may then cause serious inequality in prospects for future labour market entrants and digital citizens. The under-representation of females and girls in the STEM fields, particularly ICT, also calls for further educational actions to reduce the existing gender gaps in these well-employed sectors (e.g. Dass et al. 2015). As Cheryan et al. (2016) argue, girls should be offered early experiences with technology, digitalisation, and the professional possibilities they hold as their unwillingness to apply to these fields tends to develop at an early level of education. The same is most probably true with technology non-savvy boys. For this reason, earlier interventions aimed at reducing digital inequality should be scheduled in early stages of common basic education.

Age was noticed as a factor that predicted the level of digital skills among students of both school types. The positive effect of age was even higher among Finnish vocational upper secondary schoolers, who improved their skills during the upper secondary level studies to the extent that they closed the skills gap that existed between general and vocational upper secondary school students by the beginning of their upper secondary level studies. Instead, the development of digital skills among general upper secondary education students was found to be more diminutive. This observation is interesting, as the previous assumption was that vocational education is not as effective as academic education, in this case general upper secondary education, in terms of outcomes for including such skills (see Brunello & Rocco 2017). These findings also lead one to turn more attention to the curricula. Fenwick (2011) argued that government-led reforms in curriculum, assessments, and schooling are aimed at improving national productivity and social well-being. In general, the conceptions about future citizenship and the crucial skills citizens will need in a future society are manifested in curricula (Olson et al. 2014).

The Finnish national core curriculum for general upper secondary education seeks to deepen students' abilities, which are generally learned at the basic education level. Then these students can use, learn, and interact with digital technologies in the future (FNBE 2016). In Finland, the Matriculation Examination at the end of general upper secondary school is the only examination that can be considered as a national, high-stakes examination. Indeed, it may have a strong impact on students' later opportunities. Currently, this examination is undergoing digitalisation, and all of its sub-tests should be digitalised by year 2019. (Pollari 2016.) Understandably, this change has had a significant impact on the teaching, as teachers are now pronouncedly focusing on ensuring that their students have the needed skills to cope with the new examination.

In contrast, in common parts of the vocational upper secondary education curricula, the goal is to offer students experience in the technologies that will used in their profession and support the versatile use of computer technology as both a professional and a citizen (FNBE 2012; FNBE 2011a). The goals for digital skills in the core curriculum for vocational upper secondary education are more oriented toward students' future professions and their adult life. They are more instructive and, with all probability, more motivating for these students, and indeed that focus may cause a definite observed increase in digital skills. However, this issue needs to be more carefully examined in the future.

In general, the results of this study highlight the importance of recognising the need for teaching digital skills at all levels of education. These skills should not be viewed as a sideline of or an "extra" to more important educational goals, nor should the schools assume that all young people already have sufficient digital skills for the future. Instead, it is important to recognise the necessity of digital competence both in the work life and a civic society and work harder to promote both the equality of these skills and exploitation of the many opportunities that are available in the future.

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APPENDIX 1

Item	Description
Basic operations	Participants must pair a keyboard shortcut with a correct action and choose a correct type of computer memory for the present education situation.
Information seeking	Participants have four cases wherein they have to choose a correct source/channel, out of three offerings on where to seek further information on a given topic. After this action, they are presented with a list of search engine results and asked to choose relevant items related to a given scenario.
Information networks	Participants are given four network usage scenarios and must pair them with correct data transmission technologies and then match the correct descriptions to the computer network-related concepts.
Word processing	Participants are asked to edit (bold, italicise, underline, and/or highlight) a given sample text.
Spreadsheets	Participants are asked to fill a spreadsheet table with given information, bold a header row, and sort the table in ascending order.
Presentations	Participants are given a general user interface view of presentation software with essential sections marked. The task is to pair a correct name with the right section of this view.
Social networking	Participants have to pair correct social networking services with four service descriptions, define the meaning of social networking service, and choose four items out of nine that relate to the security of social networking services.
Communication	Participants have to fill in the receiver fields (carbon copy, and blind carbon copy) of an email, add an attachment according to instructions, then identify the types of information that can be used to identify Internet users.
Information security	Participants have to choose correct statements for secure network communication and choose from alternatives those that would relate to the information security of computers in an Internet cafe abroad.
Image processing	Participants have to select correct image processing tools for cropping an image and make the person appearing an unrecognisable image. Afterwards, participants have to choose the correct image processing using related statements from given options and choosing the correct file formats for vector graphics.
Video and audio processing	First, participants have to choose those methods that can be used to edit video footage from a single camera and then choose a right answer to the question: "Which one of these alternatives is related to lossy audio compression?"
Cloud services and publishing	In the first step, participants have to choose which of the given statements about Cloud services are true. In the second step, they must choose the correct YouTube-video sharing option that enables limited sharing even to those who do not have an account on YouTube. The third step is a continuation question: "Can we now be certain that this video does not circulate to the rest of the Internet for outsiders to see [...]?"
Software purchasing	Participants have to choose what aspects need to be considered when evaluating the information security of mobile applications and also choose the correct definition of personal data protection from four offered alternatives.
Installation and updates	In the first step, participants choose whether a statement is about an installation or an upgrade; in the second step, they choose whether that same statement is related to an update or to an upgrade.
Elementary programming	Participants have to write, per instructions, a maze traversing script that leads from a starting point to the end. Afterwards, they are presented a short pseudo-code and have to write the value of a particular variable after the given code has completed.
Database operations	Participants have to form an SQL-query, based on given instructions and a simple database diagram, and then choose the right definition for the concept 'NoSQL database'.

Web programming	Participants are given three files (HTML, CSS, and JavaScript) to use to create a website and the view generated by these three files. Participants then answer four multiple choice questions to edit the simple web page view and the dependencies between the given files.
Programming	This programming task requires the participants to place lines of Java code in the correct places based on given comment sections.

Appendix 1. ICT skills test items and their descriptions.

APPENDIX 2

	Female Students		Male Students			
Future Intentions:	**M**	**SD**	**M**	**SD**	**t**	**p**
Advanced syllabus in mathematics	13.41	4.97	14.34	6.43	-2.783	.005**
Basic syllabus in mathematics	11.48	4.79	11.30	5.94	.479	.632
Culture	15.59	5.34	17.72	5.09	-.987	.382
Natural sciences (ICT)	26.65	.35	19.78	6.67	1.424	.170
Natural resources and the environment	7.69	5.57	8.35	4.50	-.236	.815
Tourism, catering, and domestic services	8.59	4.70	8.90	4.89	-.305	.761
Social services, health, and sports	9.40	5.52	12.33	6.36	.224	.823
Technology, communication, and transportation	11.77	5.65	12.34	5.24	-.639	.523
Social sciences, business, and administration	12.51	5.53	12.20	6.34	.203	.840
** p < .01						

Appendix 2. Digital skills by educational choice and gender.

APPENDIX 3

	Female Students		Male Students			
Future Intentions:	**M**	**SD**	**M**	**SD**	**t**	**p**
Health and welfare	11.75	4.92	12.62	6.52	-1.468	.868
Engineering, manufacturing, and construction	12.03	5.47	12.14	6.18	-.139	.110
Business, administration, and law	11.90	5.44	12.23	6.06	-.574	.567
Arts and the humanities	13.43	5.16	13.48	6.29	.074	.941
Natural sciences, mathematics, and statistics	15.03	5.28	16.65	5.63	-2.077	.039*
Education	11.19	4.83	11.93	6.23	-.802	.424
Social sciences, journalism, and information	13.09	4.95	13.96	5.67	.871	.385
Services	10.71	5.09	10.65	5.82	.129	.897
Information and communication technology (ICT)	16.07	5.70	17.74	6.58	-.911	.364
Agriculture, forestry, fisheries, and veterinary	11.08	5.44	9.07	4.76	1.664	.101
* p < .05						

Appendix 3. Digital skills by future study/employment intention and gender.

Meri-Tuulia Kaarakainen

ICT Intentions and Digital Abilities of Future Labor Market Entrants in Finland

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ICT Intentions and Digital Abilities of Future Labor Market Entrants in Finland[1]

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ABSTRACT

Daily lives of citizens in current societies have changed with the spread of digital technologies, online services, and digital communication. Alongside this, the information and communication technology (ICT) labor force is expected to grow massively over the next years, requiring increased number of applicants for digital education and sufficient digital skills from every labor market entrant. This study examines the digital abilities of Finnish upper secondary school students (N = 3206) and the students' intentions to study/work in the ICT field in the future. The results highlight a dissonance between the growth expectations and the popularity of the ICT field among young Finns. The students' future intentions are also strongly gendered; for about 9% of males, but only about 1% of females in secondary education are planning to apply in the ICT field in the future. The students' ICT intentions were predicted most strongly by being a male and possessing strong technical abilities.

KEYWORDS

Digital abilities / gendered educational choices / the ICT field / programming / students

Introduction

Characteristics for the present information society are the central role of information, presence of collaborative platforms, the convergence of content across platforms, the growing importance of cyber security, mobile, and cloud computing, and the automation of routine tasks (Dass et al. 2015; Webster 2014). Along with technological development, new competence requirements have emerged and, like Berger and Frey (2016) argue, although digital skills in general are expected to increase in importance in the future, there is particularly demand for more advanced technical skills. One example is competence in software development, which has grown in importance in many countries as a result of the restructuring of the information and communication technology (ICT) field. Accordingly, not only sufficient digital skills but also computational thinking and coding have been assimilated into a set of skills required from the future labor market entrants (e.g., Bocconi et al. 2016). As a consequence, in several countries, computer science has been introduced to primary and secondary school curricula with aims to provoke computational and algorithmic thinking, teach problem solving and basics of programming, and familiarize children and young people with careers paths that the ICT field professions have to offer (Hubwieser et al. 2015).

[1] You can find this text and its doi at https://tidsskrift.dk/njwls/index.

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In the digital labor market, there is an ongoing occupational restructuring, the main drivers of which are technological development and offshoring. Due to this evolution, the demand in the labor market is shifting in favor of more educated workers (Goos et al. 2014). For example, in Finland, significant industry-level changes in the 21st century have transformed the ICT field from traditional manufacturing activities to high value-added activities including R&D and software development. These changes have not only had an indisputable impact on the labor market in the ICT field but also have even more broader implications. In this restructuring process, low-skilled workers in the ICT manufacturing and services have been gradually replaced by newer highly skilled labor in the software industry (Nikulainen & Pajarinen 2013). For this reason, at the same time, there may be both an oversupply of employees with obsolete skills and a growing demand for new kind of skills in the field.

On the basis of a forecast scenario, the ICT labor force in Europe will grow from 7.5 million in 2014 to 8.2 million in 2020. That means a need for approximately 756,000 additional workers. Of these, about 70% are expected to be ICT practitioner occupations and around 30% will be at the ICT management level. This scenario also forecasts a structural shortage of 509,000 employees caused by a lack of available and appropriately skilled applicants (Korte et al. 2014). According to a country comparison (OECD 2017), the Finnish workforce had the highest proportion of ICT specialists. Nevertheless, in Finland, there is a growing demand for software developers; it is estimated that there is an immediate need for 7000 software development professionals and the same serious lack of software professionals also harms other Nordic countries (Otivr 2018). The growing demand of digital workforce and rapid changes in skill requirements (e.g., Kauhanen 2016) necessitates bringing motivated young applicants into digital education, and challenges the educational systems at all levels. This empirical study aims to give insight into digital skills of secondary school students, especially their programming skills, and the students' willingness to study or work in the ICT field in the future. Although the subjects of the research are young Finns, it offers perspectives for wider consideration in Scandinavia, as the shortage of digital workforce affects the Nordic countries in general.

General digital abilities and online engagement

Most of the frameworks of 21st century competencies share agreement on basic competencies that citizens nowadays must have. These are, namely, collaboration, communication, versatile literacy skills, including the digital literacy, and both social and cultural competencies. These competences are also seen as vital criteria in the labor market; consequently, young labor market entrants need to acquire such skills in order to enter the workforce (van Laar et al. 2017). The recently recommended term of digital skills is not restricted just to the use of computers or other devices, but also to skills like information management, collaboration and communication, content creation, ethics and responsibility, critical evaluation and problem solving, and technical operations (e.g., Ferrari 2012; Helsper & Eynon 2013; van Laar et al. 2017).

Van Dijk and van Deursen (2014) divided digital skills into medium- and content-related digital skills. According to them, medium-related skills refer to the technical aspects needed for use of digital technology. They consist of operational skills (technical abilities to use the Internet or a computer) and formal skills (abilities to navigate and browse through the Internet). Content-related skills in turn are the substances enabled by the competence to use technology. Content-related skills consist of information skills (abilities to search, select, and evaluate digital information), communication skills (abilities to communicate and to build networks online), content creation skills (abilities to write blogs or tweets, or edit images), and strategic skills (abilities to use technology to reach goals). In the Nordic countries, girls have not been found to lag behind boys in digital competence, rather the opposite (Hatlevik et al. 2017), although in the most technical tasks, boys tend to outperform girls (Kaarakainen et al. 2018). The competencies of future citizens are primarily delivered through the education system. Therefore, as van Laar et al. (2017) disclosed, the changing skill requirements pose serious challenges to educational systems and curricula, as they necessitate the preparation of students for jobs that may not even yet exist.

Previous research of Hargittai (2010) indicates that individuals differ significantly in their digital abilities and activities they engage in online. She continues that digital abilities are linked to the frequency to which individuals engage in diverse types of online activities. According to Helsper (2012), access, skills, and positive attitudes toward digital devices and Internet are an important but not sufficient condition of beneficial use of digital technologies. Instead, more important factors are the different ways in which individuals engage with technologies, as different kinds of online activities are found to lead to different kinds of outcomes (e.g., Blank & Groselj 2014; van Deursen & Helsper 2015). Young people in the Nordic countries seem to be involved and interested in engaging with digital technology and Internet regardless of gender since, for example, the emergence of the social media has also attracted girls to active technology usage (e.g., Tømte 2011).

Helsper's (2012) corresponding fields model categorizes the technology usage based on its purpose and possible offline outcomes into the following key domains: Economic, cultural, social, and personal use. Economic use relates to commercial and information-related use and learning via digital resources, which increases individuals' abilities to gain benefits related to income or savings, employment, finances, and education. Cultural use relates to activities that increase individuals' feelings of belonging and identity, emerging as different forms of creative and productive activities related to virtual spaces of participatory cultures. Social use refers to connections to networks, which provide attention and social support for individuals. Forms of social use are, for example, online networks and group memberships built on common interests and digital communication. Personal use is associated with activities that increase resources for personality, aptitudes, and well-being, and manifest themselves as an online commitment to entertainment, self-expression, and health promotion actions. Domains are not exclusive, rather a particular use can be related to more than one domain—such as multiplayer game playing, which simultaneously represents both social (i.e., networks and group membership) and personal (i.e., entertainment and self-actualization) usage domains (Helsper 2012; van Deursen et al. 2017).

According to van Deursen and Helsper (2018), the role of online engagement together with digital skills is crucial for the benefits enabled by technology use in present societies and this is largely independent of the person's socioeconomic characteristics. Van Deursen et al. (2017) argue that it is generally assumed that some types of uses are more beneficial than others. They continue that more beneficial forms of technology use offer more possibilities and resources for individuals to move forward in career, work, education, and societal position than others. Digital inclusion policies and interventions have largely focused on economic uses, normatively valued as desirable and more profitable form of use, as the personal and social use of technologies has been assumed to be less beneficial (e.g., Blank & Groselj 2014; van Deursen & Helsper 2018). Van Deursen and Helsper (2018), however, came to an opposite view of the matter when they found that personal and social uses have the most collateral benefits to offer, as they increase overall well-being and participation in the information society.

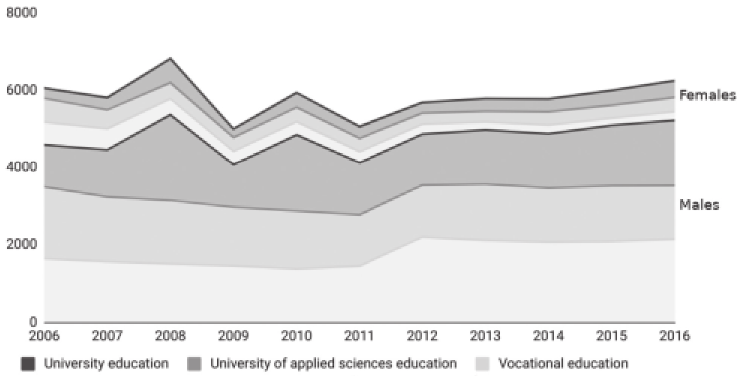
Inflows to the digital labor market

While in the case of general digital abilities the role of digital usage and engagement is essential, the skills required from digital workforce necessitate more formal learning due to the rise in the level of required competence in the field. The basic inflows in the ICT labor force come from ICT graduates from higher education, and in countries like Finland also from vocational schools of secondary education level. In fact, in Finland, there are multiple paths to gaining qualifications in the ICT field. For example, at the upper secondary level in vocational schools, students can choose the Natural Science track yielding qualifications in ICT or choose the Technology, communication, and transport track yielding qualifications in information and telecommunications technology. At the tertiary education level, the universities of applied sciences have degrees of Bachelor of Business Administration and Bachelor of Engineering majors in the ICT field. In addition, universities offer Bachelor's and Master's degrees in computer science, information systems, and engineering. These typical paths are complemented by several other kinds of training (MEC & FNAE 2017). In 2016, the ICT field was only the seventh most popular field of study and the main field for only about 9% of Finnish university students and only 18% of those students were females (OSF 2017).

The number of labor market entrants with a degree in the ICT field has not followed the trend of demand for ICT practitioners in the labor market in Europe; in fact, the number of ICT graduates has decreased since 2006 (Korte et al. 2014). As Figure 1 shows, the total number of ICT graduates in Finland has not fallen over the past decade, although it has not increased either. Due to the occupational restructuring referred in the Introduction, especially the proportion of university graduates has increased during the past decade. As a result of university degree reforms carried out during the year 2008, the number of graduates from universities suddenly, but transiently remarkably increased (Kyrö 2012). The number of university graduates increased strongly also in 2010, which was the end of the transition period of degree reform. On the basis of the official statistics of Finland (OSF 2017) about students and the qualifications of educational institutions, the gender gap in the ICT field also affects every educational level and form in Finland as shown in the Figure 1.

The European parliament reports (EP 2018) that only about 32% of current ICT workers in Europe are women. Globally, the existing gender gap has proved to be persistent; indeed, a low percentage of women majoring in computer science, computer engineering, and informatics in the Western countries not only has failed to increase but has even become lower (i.e., Vitores & Gil-Juárez 2012). Typical for European women working in the ICT sector is that they are more likely to have a higher education

Figure 1: Qualifications in ICT field in Finland during the years 2006 and 2016 by education form and gender (OSF 2017).



qualification than men (EIGE 2018). Similarly, results from Finland (Vuorinen-Lampila 2016) show that in the labor market more general, women tend to need a university degree in order to achieve equally favorable labor market status than men. Within the ICT field in Scandinavia, males reach higher positions more likely than women who more often remain in low-qualification jobs compared with men (Holth et al. 2013). This reflects the broader trend in the Nordic countries, where women continue to be disadvantaged in terms of wages and high status, despite the strong promotion of gender equality (Grönlund et al. 2017).

As shown in Figure 1, during the 10-year period of the exploration, also in Finland, the share of females has fallen among ICT graduates. In the near future, no major relief is expected in Finland, as career prospects are considered to be particularly traditional among 15-year-old Finns, as, based on the PISA report, boys are favoring technical fields and girls are preferring health care professions (OECD 2016). It should be noted that the ICT sector has not always been as male-dominated, rather the current state has evolved along with the increased status of the field. In the 1970s and 1980s, the proportion of women in the ICT sector was relatively high, as the status of the field was being low at the time. Since the emergence of the personal-computer industry and the Internet, low-skilled data entry roles were automated and men entered into the field in more higher status professions. At the same time, a male 'nerd' or 'hacker' became the stereotypical image of an ICT worker (EIGE 2018). The reasons for current under-representation of females in the ICT field are not only assumed in previous studies (Cheryan et al. 2016; EIGE 2018; EP 2012) to be rooted in women's lack of interest, skills and qualifications in the field, masculine organizational culture, and work-life imbalance, but also in these cultural stereotypes that do not offer attractive role models for girls or young women.

This study examines the digital skills of Finnish upper secondary school students and, in particular, their abilities in programming. The study also analyzes students' digital usage habits and their educational choices. The main focus of interest is in the students' future intentions to study or work in the ICT field and in which ways do the digital abilities and technology usage associate with these intentions. The research questions are the following:

(1) What are the levels of students' digital abilities in terms of medium- and content-related digital skills and programming skills?
(2) What kind are the digital technology usage habits of the students?
(3) Which variables associate with the digital skills and usage of the students?
(4) Which are the popular and unpopular fields of future education/occupation (i.e., future intentions) among students by gender and education?
(5) Which variables are the most prominent predictors of students' ICT intentions?

Methods

Participants

The data for this study were collected in Finland during 2017. Data consist of 3206 upper secondary school students' aged 15–22 years. The participants came from 43 municipalities (88 educational institutions) around the country. The municipalities were selected so that they geographically represented the Finnish municipalities. According to each of the six Regional State Administrative Agencies in Finland, small (<10,000 inhabitants), large (>100,000 inhabitants), and medium-sized municipalities were selected in terms of the proportion of the different sized municipalities in the region. Secondary schools themselves were able to decide on their participation in the research and on the participating student groups. Of participants, 69% were from general upper secondary schools, and 31% were from vocational upper secondary schools. As a whole, 52% of participants were female and 48% male students. Among the students from general upper secondary schools, female students were in the majority (female 64% and male 36%), whereas in the vocational schools, 55% of the students were male, and 45% were female. The data were collected as part of the project, Occupational restructuring challenges competencies, financed by the Strategic Research Council (SRC) at the Academy of Finland.

Measurement

Skills, usage, and future intentions were measured using an instrument called the ICT Skill Test developed in the Research Unit for the Sociology of Education (RUSE) at the University of Turku. The test started with questionnaires collecting first the students' background information (age and gender) and the form of education (general upper secondary school or vocational upper secondary school). The second questionnaire dealt with the participants' future intention: The field (ISCED-F) they desired to study or work in after graduating from their current educational plan. The third questionnaire was the digital usage habit questionnaire (usage activity, 0 = never, 1 = sometimes, 2 = weekly, 3 = daily, 4 = several hours per day, for the following specific purposes: Maintaining social relationships, communicating, running daily errands, following news, searching for information, creating digital content, sharing digital content, playing digital games, consuming digital entertainment, and studying using digital technology). Usage habit domains (economic, cultural, social, and personal use) (see Table 1) were formed, based on above-described Helsper's (2012) classification, by grouping them into the four usage domains, taking into account that certain uses associated with multiple domains. After this, the variable named versatility of daily use was calculated from the results of the questionnaire where the answer was 'daily' or 'several hours per day'.

Table 1: Items on the Usage Habit Questionnaire and their categorizations for usage domains.

Item	Economic use	Cultural use	Social use	Personal use
'I use digital technology (computers / laptops / tablets / smartphones) for: (0 = never, 1 = sometimes, 2 = weekly, 3 = daily, 4 = several hours a day)'				
Maintaining social relationships			×	
Commercial use	×			
Following current events	×			
Communication			×	
Game playing			×	×
Information seeking	×			
Digital entertainment				×
Creating digital content		×		
Sharing content online		×	×	
Learning	×			

The test was undertaken after the questionnaires. The test consists of 18 items (see Appendix 1), which are mainly based on the Finnish national core curricula for basic education. In the core curriculum, ICT competence is one of the seven transversal competencies integrated into all school subjects. The curricula aim to offer understanding of the basic operations and concepts of ICT, knowledge to use ICT in a responsible, safe, and ergonomic manner, and skills to use ICT as a tool in information management, creative work, social communication, and networking (FNBE 2016). The curriculum of the common basic education forms a basis for digital competence for all young people and further learning. That is why it also serves as a starting point for the ICT Skill Test.

Items were classified into medium- and content-related digital skills based on the framework of van Dijk and van Deursen (2014) described above. The following items were classified as medium-related skills: Basic operations, information networks, installations and updates, and functionalities of word processing, spreadsheet, and presentation software. In turn, the following items were seen as content-related skills: Information seeking, communication, video and audio processing, cloud services and publishing, image processing, social networking, information security, and software purchasing. Along with general medium- and content-related digital skills, the current study especially concentrates on those items related to programming (elementary programming, web programming, programming, and database operations). For analysis, the above-mentioned sum variables of digital skills were standardized with min-max normalization to range between 0 and 1, thus describing the average share of skill mastery from the potential maximum of the variable. Instead, the usage domain variables were left in their original scale ranging from 0 to 4, describing the average frequency of usages in particular domain.

Item analysis

Classical item analysis relies on test level (i.e., reliability and validity) and item-level statistic (e.g., item difficulty and discrimination power of the item). The coefficient alpha is the most common formula to measure internal consistency referring to the extent to which a test is a consistent measure of a specific concept described as the ratio of true-score variance to the observed-score variance (e.g., Kaplan & Saccuzzo 2017). Various threshold values for an acceptable coefficient have been presented, but these have been accused to be arbitrary and, according to Urbina (2014), there is no minimum threshold for a reliability coefficient that would be adequate for all purposes. However, basically, if all other things are equal, the higher the coefficient, the better. The Cronbach's alpha for the ICT Skill Test was 0.87, which indicates a relatively high measurement accuracy.

Validity refers to the extent to which the instrument measures what it is designed to measure. Content validity refers to the relevance of the instrument in relation to the concept to be measured. For content validity, there are no objective measures so it has to rely on the expertise of the content areas (Considine et al. 2005). In the development of the ICT Skill Test, several experts from the fields of educational and computer sciences, and user experience were involved in the development of the test contents. The relevance and the comprehensiveness of the content of the test was tested in preliminary studies involving both deliberately selected skilled and less skilled subjects. The pretesting confirmed that the test produced consistent results for skilled and less-skilled individuals.

Construct validity refers to the degree to which an instrument measures an intended theoretical concept and to a set of methods used to evaluate test items, such as item difficulty and item discrimination analysis (Kaplan & Saccuzzo 2017). Classical item difficulty refers to a proportion of participants who answer to the question correctly. High levels of correct answers (item difficulty values near 1) make the item appear easy and, conversely, low levels of correct answers (values near 0) indicate poor level of knowledge making the test item appear difficult or indicating inadequate instructions (e.g., Urbina 2014). In this study, to analyze item difficulty, an item difficulty index was used. It is considered to be more appropriate to be used with open-ended and construct-response items (Tiruneh et al. 2017), as it suits better for nondichotomous items and situations where the interest is not in the proportion of right answers, but rather on the level of participants' skills in particular item. The formula used to compute the item difficulty index (P) is:

$$P = \frac{-fX - nX_{\min}}{n(X_{\max} - X_{\min})}$$

where $\sim fX$ is the total number of scores earned by all test-takers on an item, n is the number of test-takers, X_{min} is the smallest item score possible, and X_{max} is the highest item score possible. The item difficulty indexes for the ICT Skill Test ranged between 0.01 and 0.63. The difficulty indexes for other than programming-related items ranged between 0.21 and 0.63. These results indicate that the programming-related items, including elementary programming, turned out to be extremely hard for tested participants. Kaplan and Saccuzzo (2017) argue that for most tests, items with difficulty range between 0.3 and 0.7 tend to maximize information about the differences among participants. They remind that a desirable level of difficulty depends on the purpose of the test.

As the purpose of the ICT Skill Test is not to measure age-related skills in a particular school subject, but to meet the skills requirements in real life which are not age-related, it is perfectly acceptable that the item difficulty levels of the programming-related items remain low among the students.

The item discrimination is a basic measure of the validity of an item. It is defined as the ability of an item to discriminate (or differentiate) between high and low achievers. The item discrimination index ranges from 0 to 1 and the higher the value, the better the discrimination power the item possesses (Adams & Wieman 2011; Urbina 2014). The formula used to compute the discrimination index (*D*) is:

$$D = P_U - P_L$$

where P_U and P_L are the difficulty indexes for the highest performing (*U*) and lowest performing (*L*) groups. There is no common agreement about what percentage to use to determine these groups. The optimum percentage has been stated to be approximately 27%, but anything up to 50% has been mentioned in the literature (Adams & Wieman 2011). In this study, the threshold of 27% was used to divide the highest and lowest performing groups. The item discrimination indexes for the ICT Skill Test ranged between 0.04 and 0.99, indicating problems with programming-related items, which were already known to be extremely challenging for the participants. For other items, discrimination indexes ranged between 0.30 and 0.99, indicating a strong ability to discriminate between the skilled and unskilled participants.

Item discrimination can also be measured using the item-total correlation that is the Pearson's product moment correlation coefficient between an item and the scale total calculated from the remaining items. The result of item-total correlation indicates whether an item fails to correlate with the total score; values near 0 mean that the items are likely to be extremely easy or difficult, ambiguous, or that this item is not measuring the same construct being measured by the other items. The extremely high values are also unfavorable, as an item total correlation near 1 can be considered redundant (Considine et al. 2005; Kaplan & Saccuzzo 2017). The item-total correlation values for the ICT Skill Test ranged satisfyingly between 0.21 and 0.66 and achieved statistical significance ($p < 0.001$). Altogether, the above values of reliability and validity confirm the perceptions of the satisfactory quality of the applied instrument, even though programming-related items were found to be challenging for the participants.

Analysis

The levels of digital abilities and usage were examined via means and standard deviations, and the relationships between the variables were analyzed utilizing the Pearson's correlation coefficient that is a measure for linear relationship between two variables (e.g., Rodgers & Nicewander 2003). Seeking to scrutinize the popularity of future fields of education/occupation, a visualization technique called Sankey diagram was utilized. Sankey diagrams present quantitative information about flows, relationships, and transformations. They are directed, weighted graphs with 2–n nodes, wherein the sum of the incoming weights for each node is equal to its outgoing weights (Riehmann et al. 2005; Schmidt 2008). In the current study, the Sankey diagram was used particularly to represent the relationships and connections between the examined variables. Because visualization does not adequately take into account the differences in size of the groups to be compared, the Chi-square test was used for more comprehensive analysis.

Logistic regression was used to assess the effects of independent factors (age, gender, education form, digital abilities, and usage) on students' ICT intentions, which appears as a dichotomous variable in the data. According to Peng and So (2002), logistic regression is well suited for examining the relationships between a dichotomous or a qualitative dependent variable and one or more independent predictor variables. There are several possibilities to measure the difference between the observed and fitted values, that is, the goodness of fit, in the case of logistic regression. In this study, the overall model significance for the logistic regression is examined using the Chi-square test of model coefficients. Nagelkerke *R*-squared is used to examine the percentage of variance accounted for by the independent variables. The Hosmer-Lemeshow test is also a common statistical test for goodness of fit for logistic regression models. The test measures whether the observed values match the expected values in the subgroups of the model population; the test value 1 indicates perfect fit (Hosmer & Lemeshow 2000). Mood (2010) has notified that because the coefficients of logistic regression depend both on effect size and the magnitude of undetected heterogeneity, one cannot compare coefficients between models or samples as is usually done with linear regression models. In this study, logistic regression was therefore not used to compare different models, but only aimed at detecting which independent variables explain the variance of dependent variable.

Results

Digital abilities and technology usage

As the Table 2 summarizes, on average, students succeeded in 38% of medium-related items and 42% of content-related items of the ICT Skill Test. Overall, the performance in the programming items was low; on average, students reached just 7% of scores available in programming-related items. The economic use was the most popular usage domain among upper secondary education students. This is most probably due to the fact that information seeking and using devices for learning is abundant among students in the secondary education level. The second most popular usage domain was personal use that included leisure time activities like computer gaming or listening to music or watching movies and TV series online. The social use was the third most popular usage domain including social interaction related Internet activities. The cultural use domain proved to be the least popular usage domain among students referring to activities like creating and sharing one's own digital content. On the basis of the usage habit questionnaire, on average, the students responded using digital technologies for four purposes (out of 10) on a daily basis. The use of digital technologies was found to be an essential part of the daily life of young people in Finland, as only 4% of students did not report using digital technology for any purpose on a daily basis.

Table 2 also represents the correlations between variables. It can be noticed that one type of digital skill strongly associates with other types of digital skills. Especially the correlation between medium-related and content-related skills was strong (r = 0.72). Also, programming skills correlated positively with both medium (r = 0.45) and

Table 2: Descriptive statistics and correlations (*N* = 3206).

Variable	M (SD)	1	2	3	4	5	6	7	8	9	10	11
Age	16.7 (1.23)	1										
Gender (0 = female)	0.48 (0.49)	0.01	1									
Education form (0 = Guss)	0.31 (0.46)	0.32***	0.17***	1								
Medium-related skills	0.38 (0.21)	0.09***	0.10***	−0.08***	1							
Content-related skills	0.42 (0.19)	0.09***	0.01	−0.13***	0.72***	1						
Programming skills	0.07 (0.11)	0.03	0.18***	0.01	0.45***	0.51***	1					
Economic use	1.95 (0.59)	0.15***	-0.07***	−0.11***	0.17***	0.21***	0.06***	1				
Cultural use	0.92 (0.61)	0.02	-0.04	−0.08***	0.09***	0.11***	0.09***	0.36***	1			
Social use	1.88 (0.44)	-0.01	0.03	−0.07***	0.09***	0.12***	0.03	0.40***	0.42***	1		
Personal use	1.92 (0.61)	-0.02	0.21***	0.03	0.13***	0.11***	0.10***	0.25***	0.20***	0.50***	1	
Versatility of use	4.12 (1.96)	0.05***	0.05***	−0.05***	0.18***	0.18***	0.09***	0.72***	0.48***	0.68***	0.55***	1

M = mean; *SD* = standard deviation; Guss = general upper secondary school; ***$p < 0.001$.

content-related ($r = 0.51$) digital skills. Among background variables, age had only negligible positive association with medium- ($r = 0.09$) and content-related ($r = 0.09$) skills, but no significant association with programming skills. Being a student in general upper secondary school had a slightly positive association with both medium- ($r = 0.08$) and content-related ($r = 0.13$) skills, while there was no significant relationship between the form of education and programming skills. Instead, gender had an association with programming skills ($r = 0.18$), as male students succeeded better in programming tasks than female ones. Being a male was also slightly associated with medium-related digital skills ($r = 0.10$).

When examining usage habits, it was found that female students were a little more inclined to use technology for an economic purpose ($r = -0.07$) than males, while male students were more likely to be active in the personal use ($r = 0.21$) domain than females. Like digital skills, digital usage was also found to be cumulative, as usage domains correlated clearly with each other. In particular, economic and social use strongly correlated with versatility of daily use ($r = 0.72$ and $r = 0.68$). In general, more active digital usage was also associated with increased digital skills; medium- and content-related skills were most clearly associated with economic use ($r = 0.17$ and $r = 0.21$) and versatility of daily use ($r = 0.18$ and $r = 0.18$), whereas programming skills were only slightly positively associated with usage domains and versatility of use in general, but still relatively more with cultural ($r = 0.09$) and personal use ($r = 0.10$) than social (0.03) and economic (0.06) use.

Future intentions

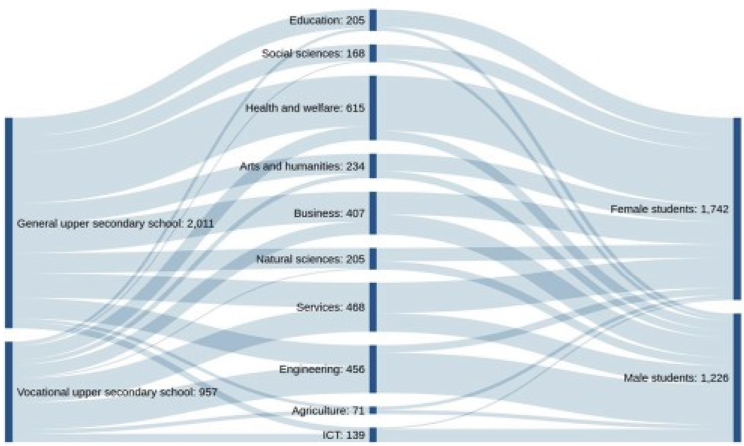
Figure 2 represents the popularity of future field of education/occupation by gender and current educational choice. The most popular field of future education/occupation among female students was health and welfare, which was a choice of 28% of female students. The second most popular field among female students was services (16%) and the field of business, administration, and law ranked third (12%). Female students also favored education (9%) and arts and humanities (9%), and to some extent social sciences, journalism and information (7%) and natural sciences, mathematics and statistics (7%). The least popular fields among female students were ICT (1%), agriculture, forestry, fisheries, and veterinary (2%), and engineering, manufacturing, and construction (4%).

By contrast, the most popular field among male students turned out to be engineering, manufacturing, and construction, which was a choice of 29% of males. The second most popular field among male students was business, administration, and law (14%), whereas the third most popular field was services (13%). Also, the ICT field attracted male students (9%). Health and welfare (7%), art and humanities (6%), and natural sciences, mathematics, and statistics (5%) ranked after the ICT field in popularity among male students. Social sciences, journalism, and information was the least popular field of future education/occupation for males (2%) followed by agriculture, forestry, fisheries and veterinary (3%), and education (3%).

The most equal gender distribution seems to be found in the business, administrative, and legal field, as the share of genders was quite even. However, the visual image shown in Figure 2 is misleading to some extent unless both the observed values and the expected values are taken into account. The Chi-square test revealed a significant difference between genders ($X^2 = 5{,}157$, $df = 1$, $p = 0.023$), and, in fact, the business sector was more popular among male than female students. When the number of female and male students in the sample in question were considered, it was found that the most gender-independent choice was the field of natural sciences, mathematics, and statistics ($X^2 = 1{,}392$, $df = 1$, $p = 0.238$). Instead, the male-dominated fields of ICT ($X^2 = 137{,}122$, $df = 1$, $p < 0.001$) and engineering, manufacturing, and construction ($X^2 = 397{,}297$, $df = 1$, $p < 0.001$) were the most gendered fields of future intentions, followed by the most female-dominated fields; education ($X^2 = 51{,}509$, $df = 1$, $p < 0.001$) and social sciences, journalism, and information ($X^2 = 38{,}291$, $df = 1$, $p < 0.001$).

Similarly, based on Figure 2, the field of services seemed to be popular among both general and vocational upper secondary school students. However, a more in-depth examination revealed that when taking into account the number of students in the sample, students from vocational upper secondary schools were more likely to choose the service sector ($X^2 = 78{,}734$, $df = 1$, $p < 0.001$) than students from general upper secondary schools. Instead, the form of education had no significant effect on the intentions to seek to the field of business in the future ($X^2 = 408$, $df = 1$, $p = 0.523$). The fields of natural sciences, mathematics, and statistics ($X^2 = 66{,}140$, $df = 1$, $p < 0.001$), social sciences, journalism, and information ($X^2 = 48{,}264$, $df = 1$, $p < 0.001$), and health and welfare ($X^2 = 34{,}545$, $df = 1$, $p < 0.001$) were most likely favored by students from general upper secondary school, whereas the intentions to study or work in the fields of ICT ($X^2 = 43{,}858$, $df = 1$, $p < 0.001$) or engineering, manufacturing, and construction ($X^2 = 160{,}007$, $df = 1$, $p < 0.001$) were dominated by students from vocational upper secondary schools.

Figure 2. Sankey diagram of the popularity of future field of education/occupation by gender and current educational choice.



The logistic regression was used to analyze the predictors of students' ICT intentions (Table 3). The odds of intentions to study or work in the ICT field in the future for males was found to be over seven times higher than the odds for females (odds ratio, $OR = 7.26, p < 0.001$). Likewise, the odds of continuing in the ICT field in the future for vocational upper secondary school students was found to be somewhat larger than the odds of general upper secondary school students ($OR = 0.411, p < 0.001$). Instead, age did not have a significant impact on ICT intentions. Among digital abilities, especially higher levels of medium-related skills predicted students' ICT intentions, as one-point growth in medium-related skills lead to an increase in odds of more than five times ($OR = 5.90, p < 0.001$). Programming skills had a similar effect, albeit to a much lesser extent ($OR = 1.525, p < 0.001$). Instead, content-related skills did not have an impact on students' ICT intentions. The role of technology usage habits proved to be less relevant compared to the background variables and the digital abilities of students. However, the abundant use of technology in the personal use domain made an exception; an active online engagement on the domain that includes personal enjoyment and expression, being more typical for males, increased remarkably the likelihood of students heading for the ICT field ($OR = 14.315, p < 0.01$). The logistic regression model was significant, $\chi^2 = 310.901$, $df = 11$, $p < 0.001$, accounting for 31% of the variance (Nagelkerke R^2) of dependent variable. A Homer-Lemeshow test was used to assess the goodness of fit of the logistic model. The test yielded a χ^2 of 5.108 with $df = 8$ and p-value of 0.747 suggesting an adequate overall fit of the model (see Table 3).

Table 3: Logistic regression model predicting the students' ICT intentions.

							95% CI	
Independent variables	**B**	**SE**	**Wald**	***df***	***p***	***OR***	**Lower**	**Upper**
Age	0.031	0.081	0.129	1	0.699	1.032	0.880	1.209
Gender (0 = female)	1.982	0.297	44.620	1	0.000***	7.260	4.058	12.987
Education (0 = general)	0.888	0.209	18.067	1	0.000***	0.411	0.273	0.620
Medium-related skills	1.775	0.329	29.055	1	0.000***	5.900	3.094	11.249
Content-related skills	−0.741	0.418	3.136	1	0.077	0.477	0.210	1.082
Programming skills	0.422	0.088	23.053	1	0.000***	1.525	1.284	1.811
Economic use	−0.150	0.993	0.023	1	0.880	0.861	0.123	6.025
Cultural use	1.114	0.695	2.570	1	0.109	3.407	0.780	11.893
Social use	0.641	1.219	0.277	1	0.599	1.899	0.174	20.703
Personal use	2.661	0.872	9.315	1	0.002**	14.315	2.592	79.073
Versatility of daily use	−0.869	1.083	0.643	1	0.422	0.419	0.050	3.505
N	3135							
Model Chi-square	310.901			11	0.000***			
Hosmer and Lemeshow test	5.108			8	0.747			
Nagelkerke R^2	0.310							

B = unstandardized beta; SE = the standard error for the unstandardized beta; *df* = degrees of freedom; *OR* = odds ratio; *CI* = confidence interval; *** $p < 0.001$; ** $p < 0.01$.

Discussion

Students' overall performance in test items requiring medium- and content-related digital skills remained, on average, rather low. Especially the participated students struggled with the items that required medium-related skills. This is probably due to the ease of use of current digital devices, as their use does not require advanced technology abilities. The level of programming skills of the students was found to be very low and only a few students succeeded in these tasks. This is understandable since programming was not part of the curricula at the time the tested students were pupils in basic education, and thus, the students were generally not expected to have these skills. The purpose of including the programming tasks in the ICT Skill Test was to find out whether or not there were students who possess these kinds of preliminary information needed in studies in the ICT field due to their own interest toward the subject. Instead, the new national core curriculum for basic education in Finland (in use since 2016) strives to offer early experiences with programming, algorithmic thinking, and problem solving to every young girl and boy during the 9-year basic education (FNBE 2016). This is undoubtedly a positive goal. Unfortunately, the first students, taught with the new curricula, will graduate from Finnish upper secondary schools at the earliest in year 2028 – that is a long time for the current labor market to wait for youngsters who have benefited from these early experiences.

On the basis if the results, digital abilities were found to accumulate, as both medium- and content-related skills and programming skills strongly correlated with each other. Digital abilities were found to associate especially with versatile use of technologies for different purposes on a daily basis and with frequent use of technologies for economic purposes such as for learning or information-seeking activities. Similarly, in previous studies, the positive role of young people's digital technology usage for their digital abilities has been identified (Hatlevik et al. 2018; Kolko et al. 2013). Like digital skills, digital usage was also found to be cumulative; the active use in one usage domain correlated with increased activity in other domains as well. It can be considered evident that digital skills and digital usage are intertwined and necessitating one another; skills enable usage and, on the other hand, usage offers the opportunity to practice and acquire new skills.

One key finding in this study is that students' educational/occupational intentions appear to be strongly gendered choices. The finding resonates with the concept of horizontal segregation that refers to the tendency of genders to concentrate in gender-specific fields of education and occupations (Triventi et al. 2015). According to Triventi et al. (2015), high occupational specificity, which is typical in educational systems with a separation between vocational and general forms of education, links education and occupations strongly together, and increases the likelihood of horizontal gender differentiation. Such an education system is not only typical, for example, for Germany but also for Finland, which makes the observation of genderedness of the students' future intentions at least to some extent expected. On the basis of the results of this study, especially intentions to apply to the ICT field were considered to be strongly gendered, as just about 1% of female students announced their intention to enter the field in future, while 9% of males reported the same.

On the basis of the results of this study, the students' ICT intentions were, in addition to male dominance, largely explained by digital abilities, especially those requiring more technical knowledge; the likelihood of students choosing the ICT field increased significantly along with higher competence in both medium-related skills and programming skills. As a consequence, it can be stated that the digital competence of students should be strengthened if more ICT applicants are sought. This is especially important when pursuing female applicants, as the technical skills of females have been found weaker than males also in several previous studies (e.g., Kaarakainen et al. 2018; van Deursen & van Dijk 2015), and low technical self-efficacy has been found to be a major barrier on females' access to STEM fields (Cheryan et al. 2016). In this respect, the results of this study emphasize the need to influence both on technical self-efficacy and on young girls' interests toward the ICT field. On this context, Cheryan et al. (2016) have emphasized the role of offering early experiences and female role models for young girls when targeting to increase women's participation in computer science and engineering.

However, this study is not able to answer why the future intentions of Finnish young people are so strongly associated with gender and seem to reproduce rather traditional gender expectations. In future research, it would be worth exploring more precisely at what age and as a result of which kind of social processes such preferences evolve. This necessitates exploring the significance of digital engagement and further digital education and labor for young people themselves and the importance of such aspects in the social relations surrounding them. The need of this kind of research is underlined by the fact that there is no tremendous difference between the genders in the amount of or interest toward digital engagement per se. Knowledge of the processes that produce differentiative gendered preferences would contribute in finding effective ways to influence the issue. More generally, the results of current study highlight a broader dissonance between the labor market growth expectations and the popularity of the ICT field among young people in Finland. As the future orientation questionnaire revealed, only fewer than 5% of students in upper secondary education are planning to study or work in the ICT field in the future. It is to be noted that excluding the agriculture, forestry, fisheries, and veterinary field, all other fields of education/occupation seem to attract young people more than the ICT field does. Interventions should be therefore directed not only at girls but also at all young people if there are aims to increase the attractiveness of the ICT field as a future career.

According to the results of this study, digital skills proved to be at least to some extent better among general upper secondary school students than among vocational upper secondary school students. The same kind of finding has also been made in the previous studies (e.g., Calvani et al. 2010; Hatlevik & Christophersen 2013). As the role of technical expertise was identified as a key element for the students' ICT intentions, it could have been expected that the ICT field would have been popular particularly among students from general upper secondary schools. However, this was not the case; instead, the students from general upper secondary schools were a minority among those who indicated their willingness to apply to the ICT field in future. Therefore, the results seem to require increased knowledge of opportunities of the ICT field professions, especially for general upper secondary school students.

Even though the current expectations in the ICT field are positive and indeed massive growth in employment of ICT professionals is predicted, it does not guarantee the actualization of these opportunities. Like Korte et al. (2014) have warned, if the currently open positions cannot be filled and a skills shortage remains year after year, the potential for growth will be lost. In any case, the current skills shortage in the ICT field cannot be solved solely with new ICT graduates; they are simply too few in numbers. Even the potential success in raising the popularity of the field among basic and secondary education students could not quickly affect the number of higher education graduates in the field. Rather the current situation calls for various kinds of updating training and retraining, continuous professional education, and lifelong learning. In addition, the shortage calls for the development of curricula at every level of education and across all education fields to meet the demands of the present society and demands of both the digital education and workforce. Nevertheless, there is a need for effective actions that can increase the popularity of the ICT field among young people in order to increase the workforce in the field and to reduce the gender imbalance in both the digital education and labor market.

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Appendix 1. The test items, description and the results of item analysis of the ICT skill test.

Item	Description	*p*	*D*	*r*
Medium-related skills				
Basic operations	Participants have to pair a keyboard shortcut with a correct action and choose a correct type of computer memory for present education situation.	0.21	0.61	0.44
Installation and updates	In the first step, participants choose whether a statement is about an installation or an upgrade and in the second step, they choose whether a statement is related to an update or an upgrade.	0.49	0.85	0.58
Information networks	Participants are given four network usage scenarios and have to pair them with correct data transmission technologies and then match correct descriptions of computer network-related concepts.	0.18	0.47	0.36
Word processing	Participants are asked to edit (bold, italicize, underline, and highlight) a given sample text.	0.54	0.99	0.48
Spreadsheets	Participants are asked to fill a spreadsheet table with given information, bold a header row, and sort the table in ascending order.	0.29	0.73	0.52
Presentations	Participants are given a general user interface view of presentation software, with essential sections marked. The task is to pair a correct name with the right section of this view.	0.31	0.80	0.52
Content-related skills				
Social networking	Participants have to pair correct social networking services with four service descriptions, define the meaning of social networking service, and choose four items out of nine that relate to the security of social networking services.	0.41	0.64	0.60
Communications	Participants have to fill in the receiver fields, carbon copy, and blind carbon copy) of an email and add an attachment according to instructions, and identify the types of information that can be used to identify Internet users.	0.46	0.80	0.66
Information security	Participants have to choose correct statements for secure network communications and choose from alternatives those that are related to the information security of computers in an Internet cafe abroad.	0.43	0.74	0.65
Image processing	Participants have to select correct image processing tools for cropping an image and make the person appearing in the image unrecognizable. Afterwards, participants have to choose correct image processing using related statements from given options and choosing the correct file formats for vector graphics.	0.33	0.58	0.59
Video and audio processing	First, participants have to choose those methods that can be used to edit video footage from a single camera and then choose a right answer to the question: 'Which one of these alternatives is related to lossy audio compression?'.	0.44	0.82	0.64

(*Continued*)

Appendix 1. *(Continued)*

Item	Description	*p*	*D*	*r*
Cloud services and publishing	In the first step, participants have to choose which of the given statements about cloud services are true. In the second step one must choose the correct YouTube-video sharing option that enables limited sharing even to those who do not have an account on YouTube. The third step is a continuation question: 'Can we now be certain the video does not circulate to the rest of the Internet for outsiders to see [...]?'	0.44	0.90	0.58
Software purchasing	Participants have to choose which matters need to be considered when evaluating the information security of mobile applications and also choose the correct definition of personal data protection from four alternatives.	0.22	0.52	0.48
Information seeking	Participants have four cases where they have to choose a correct source/channel, out of three, on where to further seek information on a given topic. After this, they are presented with list of search engine results and are asked to choose two relevant and reliable results related to given scenario.	0.63	0.55	0.39
Programming skills:				
Elementary programming	Participants have to write, per instructions (L = 90 degrees to the left, F = one step forward...), a maze traversing script that leads from the starting point to the end. After this, they are presented a short pseudo-code and they have to write the value of a particular variable after the given code has completed.	0.09	0.30	0.43
Database operations	Participants have to form an SQL-query, based on given instructions and a simple database diagram, then choose the right definition for the concept 'NoSQL database'.	0.05	0.17	0.21
Web programming	Participants are given three files (HTML, CSS and JavaScript) to use to create a website and the view generated by these files. Participants then answer four multiple choice questions to edit the simple web page view and the dependencies between these given files.	0.08	0.28	0.26
Programming	The programming task requires the participants to place lines of Java code in the correct places based on given comment sections.	0.01	0.04	0.25